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Heating Piping & Air Conditioning

DESIGN
INSTALLATION
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INDUSTRIAL
COMMERCIAL
AND LARGE
BUILDINGS

99: Journal Section of the American Society of Heating and Ventilating Engineers

Air conditioning in industry is helping to win the battle of production

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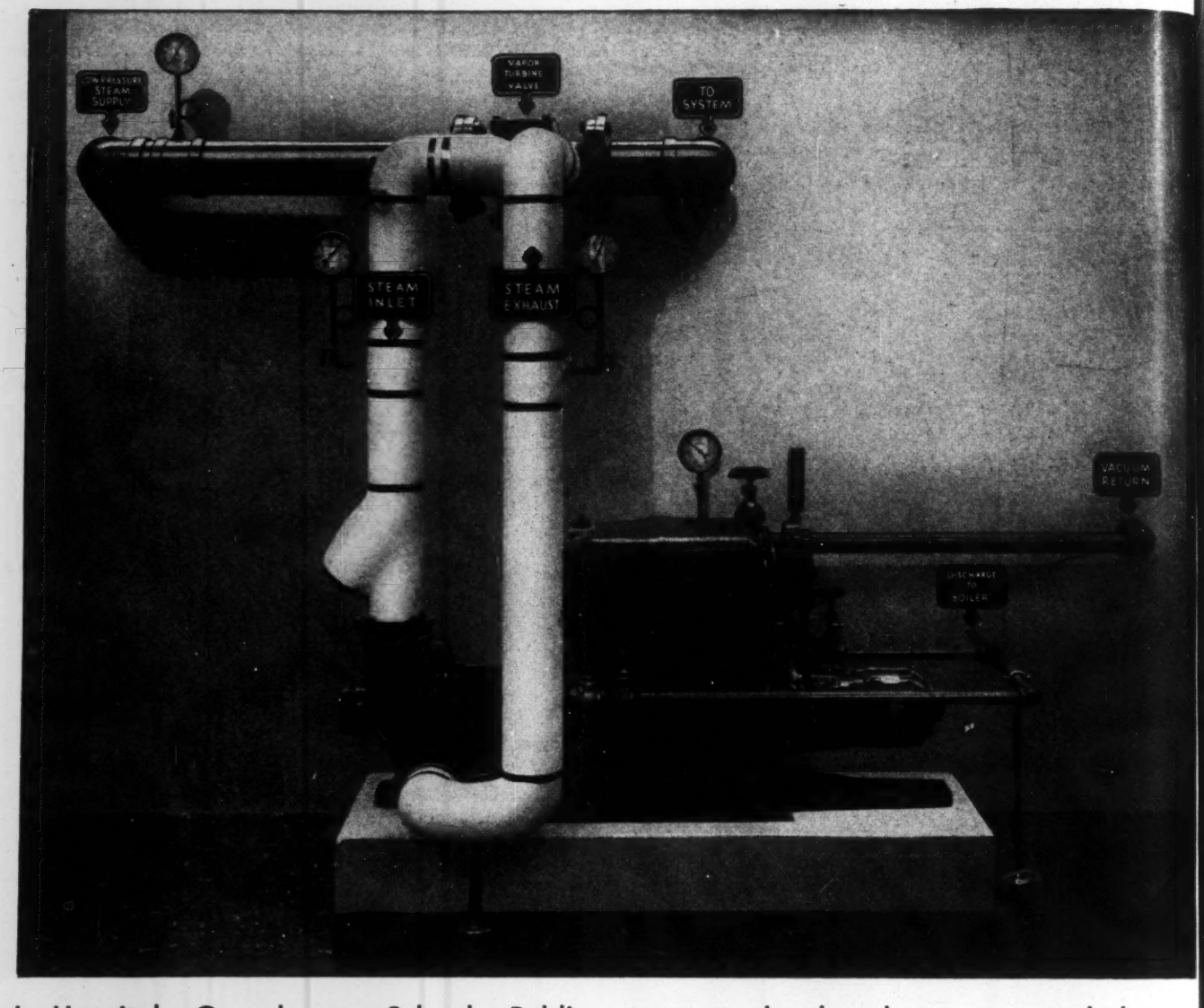
Interrupted Electric Service will not stop this NASH Heating Pump!



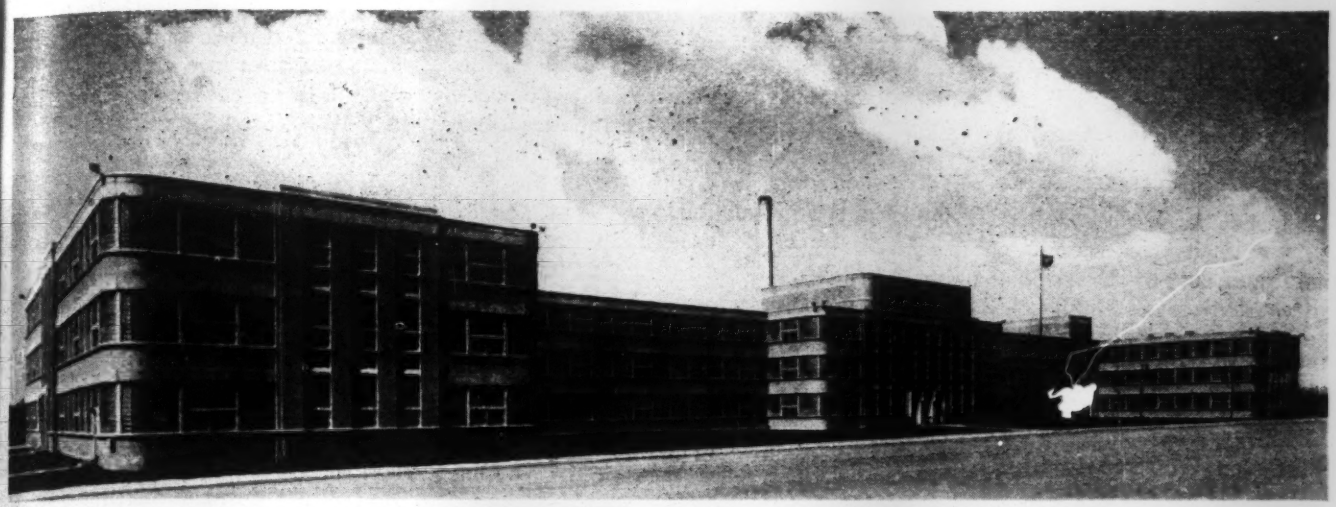
In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

This is because the prime motive power of this economical pump is a special steam turbine, controlled by a unique "Vapor Turbine Valve", which automatically bypasses from the heating main a small portion of steam, the exact amount necessary to develop the power needed to remove the condensate and maintain the required vacuum on the system. Even this small amount is passed immediately back to the mains, and goes on to the system with little heat loss. This pump operates on any system, high or low pressure.

The Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump. Bulletin on request.

THE NASH ENGINEERING COMPANY

205-A WILSON ROAD, SOUTH NORWALK, CONNECTICUT, U. S. A.



Most of the window area is glass brick

Process Air Conditioning

Production of Optical Lenses Requires Temperature, Humidity, and Dust Control

MODERN WARFARE calls for vast amounts of optical equipment. As a result, there has been a spectacular increase in the production of equipment dealing with transmission and concentration of light rays—as in telescopes, spot lights, lenses for cameras used in aerial survey work, projectors for enlarging and analyzing aerial photographs, etc.

Early in the war production program, the Defense Plant Corp. selected Bell & Howell Co., manufacturers of photographic precision equipment, to design and operate a highly specialized plant near Chicago for the production of optical lenses. It is equipped with complete year 'round air conditioning.

The building is three stories high, of reinforced concrete and brick, with most of the window area made of glass brick. It is not the blackout type; the air conditioning was necessitated by requirements for precision manufacturing rather than for human comfort.

The many manufacturing processes (particularly lens grinding, one of the most exact and delicate operations in modern industry) must be carried on under controlled air conditions. Air cleanliness, controlled temperature, and controlled relative humidity are essential for the protection of the lens from contamination and damage during its various stages of production.

The architects of the plant were Mundie, Jensen, Bourke & Havens, with the author serving as mechanical engineer for the architects.

The fundamental requirement in the design of the plant was the maintenance of a winter condition not colder than 70 F dry bulb, with 30 per cent relative humidity; and a summer condition of not warmer than 80 F dry bulb, with 55 per cent relative humidity. These conditions must prevail simultaneously in the relatively cool ground story and in the top story with its enormous roof exposure. They were not particularly difficult to fulfill.

The next stipulation was not so easy. It called for the segregation of any unit of about 1200 to 1800 sq ft of floor throughout the manufacturing areas of the building and the maintenance in that zone of a temperature of 15 F warmer or

The needs of wartime production have proved the importance of process air conditioning. An example published last month described the air conditioning requirements of the core storage room at a big magnesium foundry; another example is optical lens manufacture, requiring control of temperature and humidity both winter and summer and careful elimination of dust the year 'round. The story is told here by Samuel R. Lewis, consulting engineer and member of HPAC's board of consulting and contributing editors, who served as mechanical engineer for the architects . . . Wartime manufacturing experience with optical and photographic equipment will be utilized to advantage in the days of peace to come, and air conditioning will undoubtedly serve this important industry to an ever-increasing extent as its advantages become widely demonstrated and appreciated.

cooler than the balance of the building, with commensurate changes in relative humidity.

Another stipulation demanded that the temperature in cold weather, when the general heating and ventilating system may be shut down, could be economically and automatically maintained above a minimum of 40 F without using direct radiators. Finally, there was to be no atmospheric dust introduced from outdoors or transmitted between partitioned-off compartments of the building.

Seven Air Supply Systems

The plant as designed and installed has four main air supply systems situated in three pent houses above the roof. In addition, there are three smaller air supply systems for special services.

Each of these plants has an outside air intake, a recirculation air intake, an air filter, a tempering convector, a humidifier, a fan, and a motor. Each has discharge ducts for delivering air supply to the rooms or zones on all three stories, and corresponding ducts bringing return or exhaust air back to the respective exhaust fan. The exhaust fan may return the air to the corresponding supply system or may waste it outboard in any desired proportion.

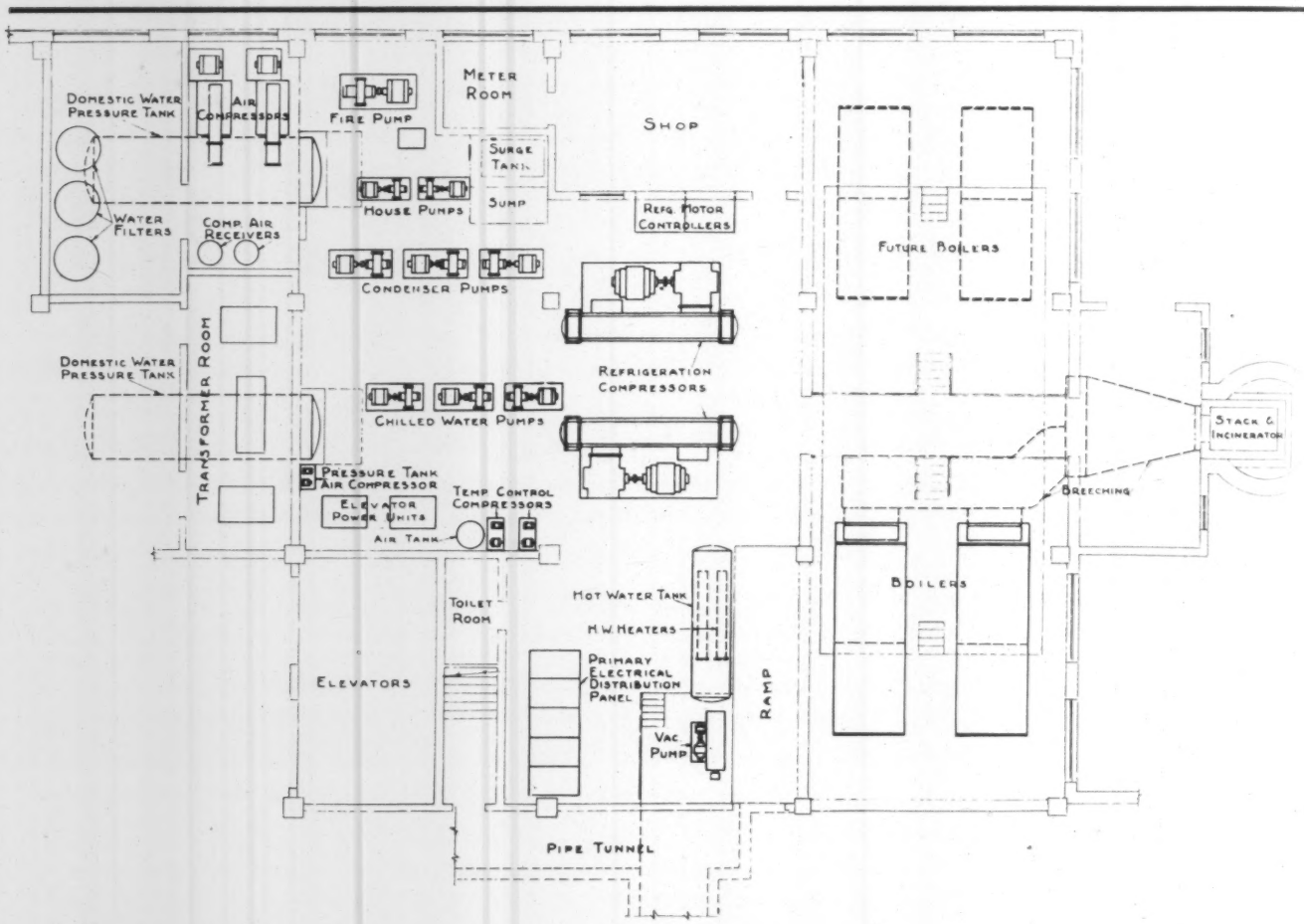
Each of three main air supply fans serving the factory (the fourth serves the office wing) delivers the air into the ducts at approximately 65 F in winter and approximately 60 F in summer. The relative humidity is controlled in winter by boiling city water in the main airways, and in summer by controlling the temperature of the air chilling surfaces so as to condense as much as necessary of the vapor inherently present in the air.

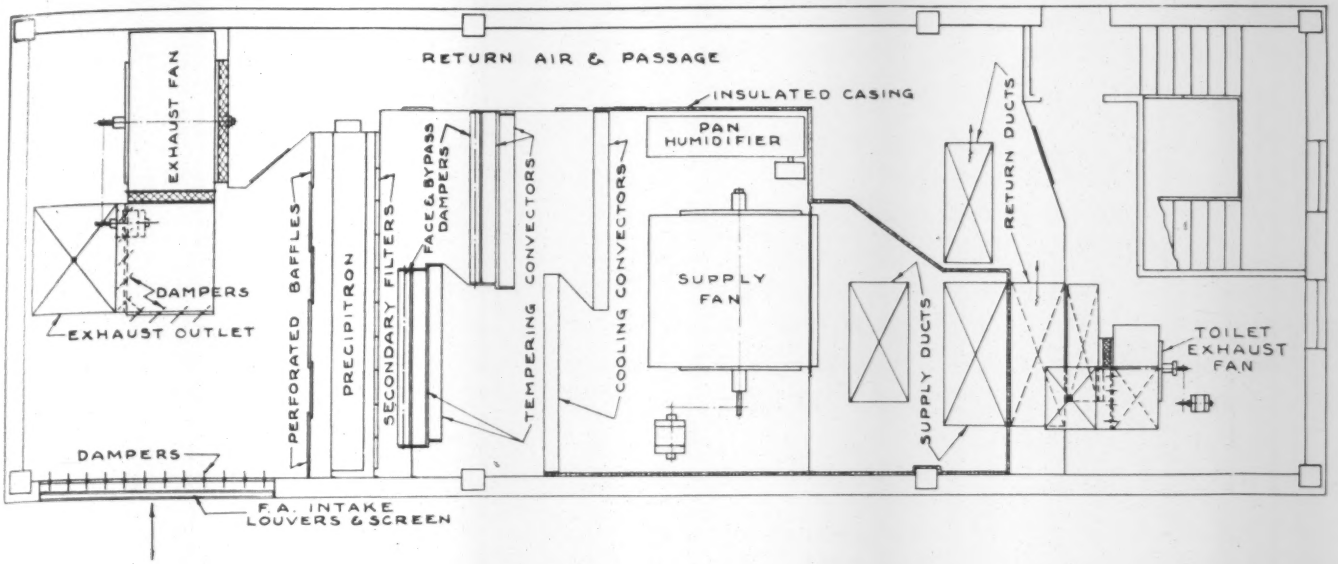
There are two 350 ton centrifugal compressors, each driven by a 350 hp induction motor. Their function is to transfer the cooling effect of 2800 gpm of condensing water sent to the cooling tower, to 700 gpm of water cooled about 12 F which removes the heat and moisture from the building

The filtered and partially conditioned air reaches horizontal trunk ducts overhead in each story. These are all large enough so that they may be entered by men for cleaning.

How the Air Is Distributed

The trunk ducts have branch ducts or in some cases have direct openings and diffusers delivering the air into the various bays or zones where special separate temperatures are desired. Each of these air passages from the trunk duct has a reheating convector controlled by a local thermostat, so that great local flexibility as to temperature is obtainable, and by elaborating the distributing ducts beyond the reheating convectors it becomes possible to obtain maximum adjustment of air delivery to compensate for variations in intensity of occupancy, changes in partitions, and modifications in process. By furring down the corridor ceilings (where corridors exist) the trunk air supply ducts are unobtrusive. The corridors





themselves generally are used as recirculation ducts.

About one-fifth of the air delivered by the supply fans is outside air during the coldest or hottest weather, and the amount of outside air delivered is automatically increased to 100 per cent when the outside air condition approaches closely to that desired for delivery from the supply systems. This is accomplished with the aid of outdoor, remote readjusting, master thermostats. This arrangement promotes very important economies in power for refrigeration and in fuel for heating and is, of course, not unusual in any well designed apparatus.

How Heat Enters or Leaves the Building

The unique feature of the installation is the use of steam for carrying heat into the building and of refrigerated water for carrying heat out of the building. The combination of the two heat carriers has several advantages. Thus, when heating, the various tempering convectors in the pent houses easily are controlled by valves and there is little danger of freezing. The reheating convectors near the air supply diffusers for the various departments are heated by steam, so that during shutdown hours, the building can be kept warm with a minimum of fuel, using 100 per cent recirculation and without necessity of operating water heating convectors, circulating pumps, and the like.

In summer, the surplus heat is removed from the building by contact with chilled water at about 48 F temperature. The chilled water is pumped through insulated mains from the centrifugal condensing machines in the machinery room and the heat thus carried out of the building eventually is dissipated into the great outdoors through a second pumped water circuit between the condensers and the cooling tower. This mechanical draft device is placed above a reservoir at grade level. It cools 2800 gpm of water from 92.5 to 85 F, if the surrounding air is at 75 F wet bulb temperature.

There are four main air supply systems situated in three pent houses on the roof. In addition, there are three smaller air supply systems for special services. Here is a typical fan room

The tower serves two 350 ton centrifugal refrigerating machines, each driven by a 350 hp induction motor. Their function is of course to transfer the cooling effect of the 2800 gpm of condensing water sent to the tower, to 700 gpm of water cooled about 12 F and sent to absorb the heat from the building and to condense the undesired moisture out of the air in the building. The cooling system has operated admirably during hot weather. During the winter, all of the water in both circuits is easily drained out.

Heating is accomplished by two oil burning boilers, each rated to evaporate 6250 lb per hr of water and capable of being operated at up to 125 psi pressure. Space is provided in the boiler room and capacity is allowed in the chimney for future additional boilers.

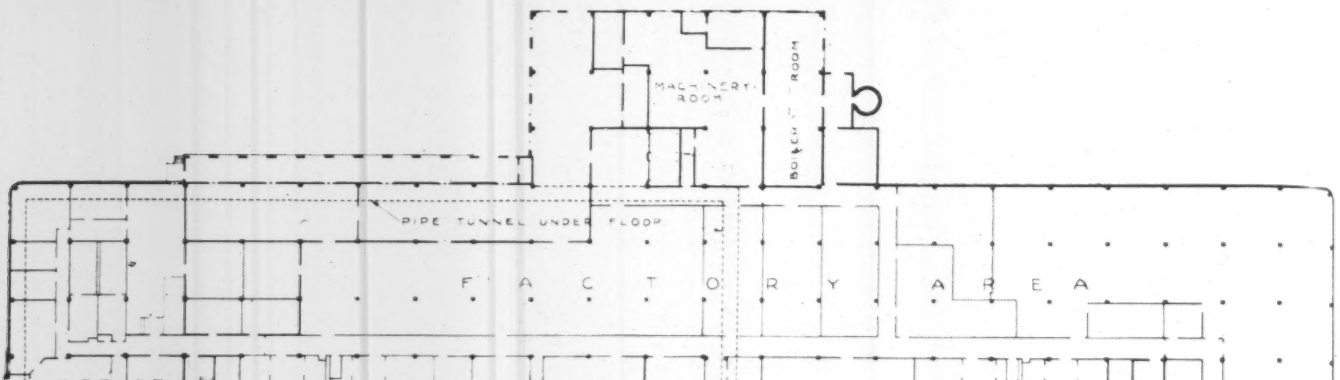
In the base of the chimney there is provided a built-in rubbish incinerator fitted with an economizer for warming partly the domestic hot water on its way to the very large steam heated storage tank. The demand of hot water for process purposes is considerable.

Electrostatic Dust Precipitators Plus Viscous Filters

The manufacturing processes require especially that air borne dust shall be minimized; this applies not only to dust entering with the outside air required for ventilation, but also to dust resulting from grinding operations in the various departments. To eliminate this dust, the factory air supply systems are all equipped with electrostatic dust precipitators, plus viscous air filters, and in addition some of the departments have local secondary dust filters in series with the individual conditioned air inlets.

Office System Separate from Factory

The offices occupy three stories of one large wing of the building. They have direct steam radiators under individual automatic tem-



perature control. The office ventilating system is independent of the factory system, except that refrigerated water for summer cooling and dehumidification comes from the apparatus which serves the entire building.

Since the plant at present is rather remote from restaurants and stores, a cafeteria capable of serving all of the employees is maintained, complete with a kitchen and officers' conference rooms. This department, and the tool room, as well as a highly specialized glass annealing room, have separate ventilating equipment permitting economical operation at intermittent hours.

Since the city water pressure at times during the summer months is extremely low, booster pumps were installed in connection with the large pressure tanks. The tanks are buried under the floor with the heads accessible from pits in the machinery room. The pumps operate automatically, controlled by pressure switches. The pump suction is against atmospheric pressure only, taking water from a concrete surge tank which receives city water through a float valve.

While grinding lenses, the grinding compound periodically is washed off. Any sand or gritty particle from the water system, if it remained on the lens, would scratch the polished surface and might ruin the work. For this reason all water, hot and cold, supplied to the production area of the plant is filtered. Water to washrooms, toilets, etc., is not filtered.

A fundamental requirement of the design of this plant was the maintenance of a winter condition not colder than 70 F dry bulb, with 30 per cent relative humidity, and a summer condition of not warmer than 80 F dry bulb, with 55 per cent relative humidity. Air cleanliness is essential

Electric Service and Lighting

The electric service to the building is from the utility company's transformers outside the machinery room. The service enters the building at 4160 volts, three phase, and is distributed to five transformer banks and to the two 350 hp refrigeration compressor motors at this voltage.

The transformers within the building are of the air cooled type. The secondary distribution is at four wire, three phase, 208/120 volts, with lighting and power taken from the same distribution cabinets. Capacitors were installed in the transformer rooms serving the manufacturing area to increase the power factor, since there are hundreds of fractional horsepower motors.

The lighting throughout the office and manufacturing areas is fluorescent, with ceiling type fixtures. In the manufacturing areas the fixtures are mounted on wiring raceways and are arranged so that if the maximum number of fixtures is installed, a minimum intensity of 40 foot candles can be obtained. The lighting intensity requirement governed the number of fixtures for each department.

The receiving, shipping, and storage rooms in the first story were provided with automatic sprinklers and an automatic fire pump for fire protection. The remainder of the building is served with stand pipes, hose, and racks.

● **IN THE "POSTWAR WORLD," *no business which depends upon attracting* the public within its doors will be doing its best job unless it can display *some* such sign as this one. Plans for air conditioning old and new buildings should be initiated now. Many organizations have already completed drawings and specs. It's never too early to plan for the future!**

HOW TO WATCH FUEL USE

Establishing a Standard

W. S. Bard, author of this article, has done a great deal of work in applying statistical methods to steam and fuel consumption studies and control, and will be remembered for discussions of the subject published in HPAC in 1937. During the period when the work described in the present article was performed, he was employed in the steam generation and distribution section at a large ordnance plant, and the method he discusses is in daily use at this plant . . . Careful control of fuel and steam consumption for heating plants and buildings is always good business; in wartime, it becomes of increased importance because of the greater necessity for efficient production and operation, conservation of fuels, and because of fuel oil rationing restrictions.

IN ORDER to control fuel consumption for plant and building heating, there must be a standard against which to compare the consumption for each report period. Since fuel consumption varies with the outside temperature, this standard must take into account variations in temperature. If records of past consumption over a representative period of time are available, and temperature reports for the same period are obtainable, these data may be used to define such a standard.

Method Applied on Daily Basis to Ordnance Plant

In 1937 the author described in these pages* a method for analyzing the efficiency of fuel consumption based on the simple correlation of steam consumption and degree days. This method was applied on a monthly basis to a group of university buildings. The method has now been applied on a daily basis to the oil consumption figures of a large war plant. This plant consists of several separate and distinct shell loading lines, each equipped with its own boiler house. Each line is made up of a group of widely scattered typical industrial buildings heated mainly by standing radiation.

High pressure steam, generated by several oil burning boilers in each boiler house, is carried through overhead transmission lines to the various buildings, where its pressure is reduced. This steam is used not only for heating the buildings, but also for heating hot water and for certain processing uses.

The oil burned in each boiler is metered, as is the amount of feedwater supplied to the boilers in each boiler house. Daily records are kept of the amount of oil burned, the amount of feedwater supplied, and the number of hours of boiler operation for each boiler house. The plant weather station supplies accurate records of daily temperatures.

The commonly accepted method for analyzing the efficiency of heating fuel consumption is to divide the fuel consumption for a standard period by the total number of degree days for that period to obtain the fuel consumption per degree day. Often this figure is in turn divided by the cubage or total EDR for the building unit under consideration. The resultant figure reduces the data to a form permitting unit to unit and period to period comparisons of performance.

If heating fuel is not measured separately from fuel used for non-heating purposes, and if the non-heating uses are a relatively large proportion of the total load, such division is not valid, since the resultant figure will vary greatly in size, decreasing during periods with a large number of degree days and increasing disproportionately in periods with a small number of degree days. The method herein described is free from this inaccuracy and is valid whenever the non-heating load remains relatively constant from period to period.

Why the System Is Used

The primary purpose of the system as described here is to furnish the executive to whom the reports on fuel consumption are submitted a standard upon which to judge in which units (if any) fuel consumption is excessive on each day, and to indicate the reason that it is excessive insofar as is possible from analysis of the data received. He can thus determine the cause and correct the excess.

A secondary use of the system is for estimating future fuel consumption for budgeting purposes and for routing fuel shipments.

A still more important use of the system is as a standard for judging the results achieved through a conservation effort, if such an effort is deemed advisable.

The "Normal" Consumption Curves

In order to set up the method for analyzing fuel consumption a basic period must be selected during which there are no significant trends in consumption and in which all ranges of degree days are represented. The period from September 20, the beginning of the heating season, to December 31, 1942, was selected for this study. During this period the general level of activity remained relatively constant on all of the loading lines and days with from 0 to 60 degree days were encountered.

The first step is to plot a scatter diagram on ordinary graph paper with oil consumption as a function of degree days (Figs. 1 and 2) for each unit. The relationship between consumption and temperatures is readily apparent from inspection of the scatter diagrams.

Next, a curve is sketched in free-

*An Accurate Method for Control of Heating Fuel Costs, and Technical Problems in Analyzing Fuel Consumption, by W. S. Bard, HPAC, August and September, 1937, respectively.

hand to represent this relationship; this curve will seldom be a straight line. A straight line was found to describe the relationship satisfactorily in the range of 20 to 40 degree days per day. The extension of this straight line above and below this range was not satisfactory. In the range of 40 to 60 degree days most of the observations lay below the curve and in the range of 0 to 20 degree days most of the observations lay above the curve. This indicated that the average overall efficiency of the entire heating system increased during the colder weather when the load was heavy and decreased during mild weather when the load was light. The curves were bent slightly at either end to express more adequately the relationship in these ranges, so that the curves were concave upward in the range of 0 to 20 degree days, nearly straight in the range of 20 to 40 degree days, and concave downward in the range of 40 to 60 degree days. The curves are so placed that approximately one-half the observations lie on either side.

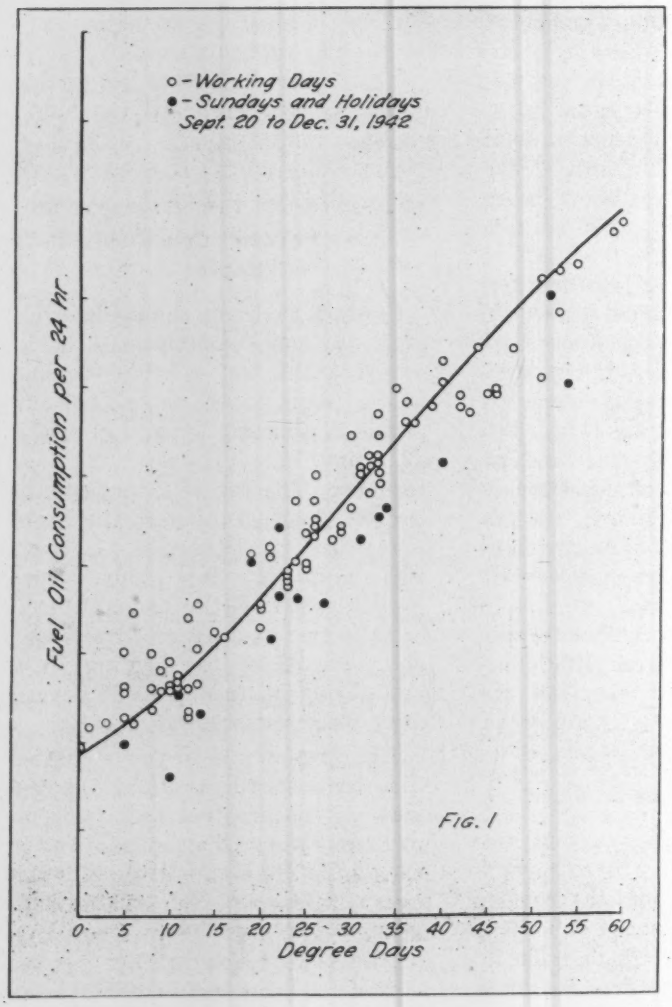
Since there was a noticeable drop in fuel consumption on Sundays and holidays the observations for these days were identified by a different symbol and these observations were ignored in fitting the curves.

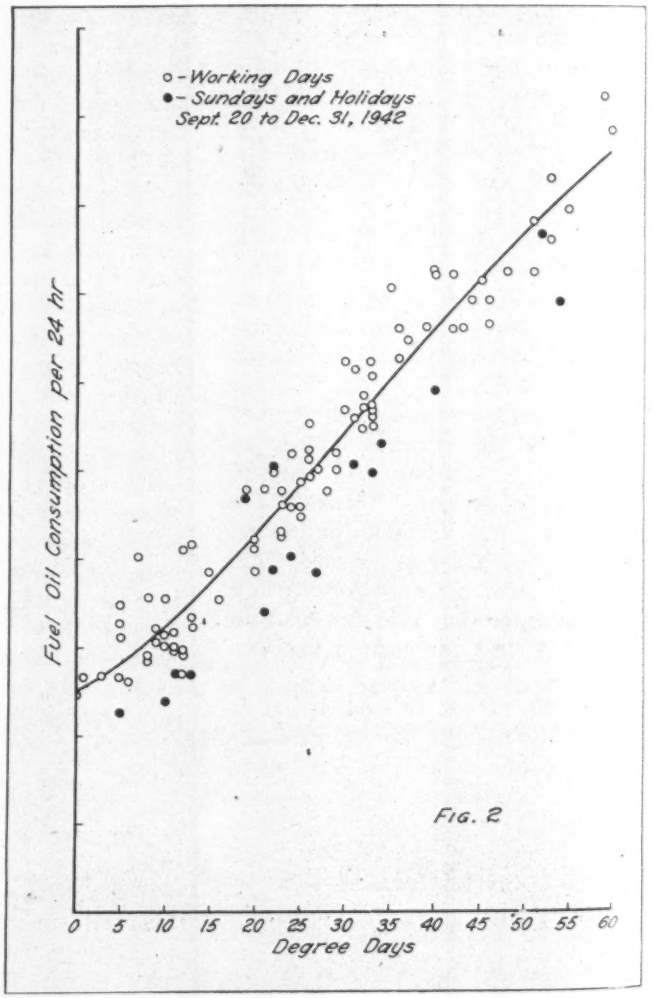
The "normal" daily oil consumption for each boiler house from 0 to 60 degree days per day was then read off the curves and entered in a table. These figures were rounded off to the nearest 10 gal interval for ease of computation. These figures represent the average or "normal" amount of oil that was burned during the basic period on days having a corresponding number of degree days.

The "Normal" Deviation

Knowing the "normal" oil consumption for any day with a given number of degree days, it is possible to compute the deviation of actual consumption above or below "normal" for each day. Since the "normal" oil consumption on any given day varies considerably from boiler house to boiler house, it is desirable to find some means of reducing these deviations to a common basis so that boiler house to boiler house comparisons of performance can be made. This might be done by representing the deviation of actual consumption from "normal" on any given day as a percentage of the "normal" for that day. Inspection of the scatter diagrams indicates that the absolute

Figs. 1 and 2—Daily fuel oil consumption plotted as a function of daily degree days. Note that the relationship can be described by a smooth curve drawn in such manner that about one-half of the observations for weekdays lie on either side. This curve represents "normal" daily fuel use


o - Working Days
• - Sundays and Holidays
Sept. 20 to Dec. 31, 1942
Fuel Oil Consumption per 24 hr
0 5 10 15 20 25 30 35 40 45 50 55 60
Degree Days
FIG. 1


o - Working Days
• - Sundays and Holidays
Sept. 20 to Dec. 31, 1942
Fuel Oil Consumption per 24 hr
0 5 10 15 20 25 30 35 40 45 50 55 60
Degree Days
FIG. 2

size of the deviation tends neither to increase nor to decrease through the various ranges of degree days. Hence, day to day comparisons of such a figure would not be valid as the size of the deviation expressed as a percentage of "normal" would tend to decrease with increasing degree days.

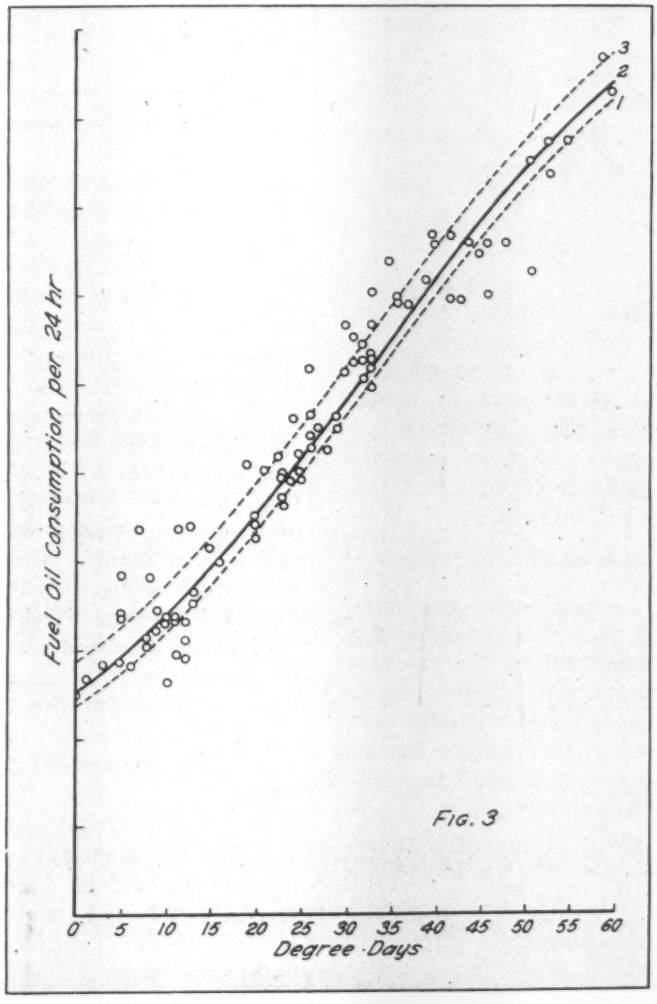
Since the range of variation of the deviations remains relatively constant through all ranges of degree days, it should be possible to compute an average deviation from "normal" during the basic period and compare the actual deviation with this average.

Because it is easily computed, the quartile deviation or semi-interquartile range—to use statistical terms—is used as a measure of average deviation. The "quartiles" are the points so chosen that the individuals of a series when arranged in order of magnitude are divided into four equal parts. If the deviations of actual consumption from "normal" during the basic period are arranged in order of magnitude, the quartiles may easily be located by counting through the series. The quartiles may be represented graphically as curves parallel to the curve of "normal" consumption and so located that one-fourth of the observations lie below the first quartile and three-fourths lie above it, and three-fourths of the observations lie below the third quartile and one-fourth lie above it. The second quartile is the median, the curve which is so placed that one-half of the observations lie on either side, and is in this case the "normal" curve (Fig. 3).

Where there are a large number of observations, the quartiles may be located most easily by graphical means. This is done by drawing in the scatter diagram a number of curves parallel to the "normal" curve and at set intervals from it, and handling the observations as in a frequency distribution.

The semi-interquartile range is one-half of the distance between the first and third quartiles. This distance is called the "normal" deviation. For ease of computation this figure was also rounded off to the nearest 10 gal interval.

Fig. 3—Daily oil comsumption and degree days showing location of quartiles. This graph is for the unit shown in Fig. 2. The lower dotted curve (1) represents the first quartile, the curve below which lie one-fourth of the observations. The upper dotted curve (3) represents the third quartile, below which lie three-fourths of the observations. Curve 2 represents the second quartile, and is also the "normal" daily oil consumption curve. All three curves are parallel. One-half of the vertical distance between curves 1 and 3 is the quartile, or "normal," deviation



The Deviation Ratio

It is now possible to compare the actual deviation each day with the average or "normal" deviation. This is done by dividing the actual daily deviation by the "normal" deviation to form the deviation ratio.

The "normal" consumption curve represents the average amount of oil burned during the basic period for any given number of degree days. The "normal" deviation represents the average deviation of actual consumption from "normal" during this same period. The "normal" curve, by its shape and slope, and the "normal" deviation, by its size, represent the peculiarities of consumption of the oil burning and steam consuming equipment which they measure.

The purpose of the deviation ratio is to reduce the individual daily oil consumption figures to a form which permits day to day and boiler house to boiler house comparisons of performance.

As a measure of the *relative* heating load in the various units, the average slope of the "normal" curves in the range of 20 to 40 degree days may be used. This figure is the average oil consumption per degree day for heating through this range. The average oil consumption per degree day throughout the entire range is less than through this limited range, since the slope of the "normal" curves decreases at either end.

The size of the "normal" deviation was compared to the slope of

the "normal" curve in this range for each unit and was found to be closely related. The ratio of the size of the "normal" deviation to the slope of the "normal" curve was nearly constant in all units, being slightly less than 2 to 1 in all but two of the units which have an abnormally high non-heating load. In these units the ratio was about 2⅓ to 1. This suggests that while a system such as this is being set up it would be valid to divide the deviation of actual consumption from "normal" by some multiple of the slope of the "normal" curve to obtain a ratio permitting unit to unit comparison until such time as sufficient data were accumulated to permit the computation of a more accurate measure of average deviation.

During the basic period there were 87 working days and 16 Sundays and holidays. The observations for Sundays and holidays were ignored in fitting the "normal" curves. After the curves were fitted, the distance of each of these observations from "normal" was measured and the median deviation found. This figure is used as the average "Sunday deviation." In computing the "normal" oil consumption for these days the "Sunday deviation" is subtracted from the "normal" value for the appropriate number of degree days.

The daily deviation ratio was then computed for each of the 103 days during the basic period for each unit. The distribution of the ratios for all units during the basic period was as shown in Table 1. All units conformed closely to this distribution.

If the distribution of the deviations about the "normal" curves fitted the normal curve of error, 50 per cent of the ratios would lie within the range of ±1.0 and 95 per cent of the ratios would lie within the range of ±3.0. The distribution is wider than normal, since only 87 per cent of the ratios lie within the range of ±3.0. Nor is the distribution quite symmetrical, being skewed slightly positively, so that the distribution is wider on the positive side of the "normal" curves than on the negative side.

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The deviation ratios may be pictured graphically if curves parallel to the "normal" curve are laid off distant from it by multiples of the "normal" deviation. The size of the ratio locates the observation with reference to these curves. A ratio of +1.4 indicates that the observation lies between the first and second curves above the "normal" curve. The mathematical probabilities based on experience are that approximately one-half of the time actual consumption will be within the range represented by one "normal" deviation on either side of the curve, three-fourths of the time actual consumption will be within the range represented by two "normal" deviations, 87 per cent of the time will be within three "normal" deviations, and 93 per cent of the time will be within four "normal" deviations. On the basis of this distribution, and assuming that consumption must be erratic at least part of the time, ratios over ±3.0 may be regarded as significant departures from "normal," while ratios over ±4.0 may be regarded as indications that consumption is greatly in error. However, the full significance of the ratios becomes most apparent when the daily deviation ratios for all units are compared.

Steam Consumption in Summer

During the summer or non-heating season, steam is consumed by the hot water heaters, the processing equipment, and by line losses. The amount of fuel consumed remains fairly constant from day to day. The data on non-heating consumption may be subjected to a treatment similar to that used for the heating data. The consumption during the period from July 1 to September 19, 1942, was used to determine the average (median) daily non-heating consumption for each unit. There was a noticeable drop on Sundays so that the observations for these days were ignored while computing the median. The non-heating "Sunday deviation" was found by computing the difference between the median Sunday observation and the median daily non-heating consumption. The quartiles were located and the "normal" non-heating deviation computed. The following was noted:

1) The size of the average or "normal" deviation was considerably less during the non-heating than during the heating season.

2) The non-heating "Sunday deviation" was less than the heating "Sunday deviation."

3) The average or "normal" daily non-heating consumption is less than the "normal" heating consumption for zero degree days (the Y-intercept of the "normal" curves); that is, the average underlying constant usage each day during the heating season is more than the average daily usage during the non-heating season. This additional underlying usage during the heating season was thought to be the additional line losses of the heating system piping. Whenever the heating system mains are turned on the piping condenses a certain amount of steam regardless of the number of radiators turned on. This amount is nearly constant. While it serves to heat the buildings, it is heat delivered regardless of whether necessary or not. This accounts in part for the curvature of the "normal" curves in the lower degree day range. If the "normal" curves are extended as a straight line from the 20 to 40 degree day range to intercept the Y-axis this point of interception will be very close to the average non-heating usage.

The system of daily checks upon fuel consumption developed from this system will be described in a second article and the general conclusions from the entire study will be summarized.

Table 1

Range of Ratio	Over +4.0	+3.9 to +3.9	+2.9 to +2.9	+1.9 to +1.9	0.0 to +0.9	0.0 to −0.9	−1.0 to −1.9	−2.0 to −2.9	−3.0 to −3.9	Under −4.0
Frequency, Per Cent of Total	3.5	3.5	7.5	12.5	23.0	26.5	12.5	5.0	3.0	3.0

"OPEN for DISCUSSION"

Prominent Contractor Sees Big Postwar Part for Radiant Heat

THE EDITOR—

The ever-increasing interest in radiant heating should be cause for serious thought in the heating industry.

Inasmuch as our very existence depends on radiant heat from the sun, it seems strange that this type of heating has received so little attention and development by the industry.

The answer must be that ever-recurring indictment of heating contractors being poor salesmen. They always seem to follow the lines of least resistance, and are quite generally willing to let others do their selling for them. So the manufacturer's salesman, having no particular specialties to sell in connection with 100 per cent radiant heating systems (other than boilers and controls) has been a great influence in directing the trend in the opposite direction.

It was only a few years ago that the American Society of Heating and Ventilating Engineers gave any attention to this subject, and this was due to the fact that up to that time the heating industry did not seem to take any interest in it. Also, the fact that some English patents seemed to require the payment of royalties on some types of radiant heating installations might have been a further deterrent to advancement of interest in such systems in this country.

The ASHVE Heating, Ventilating, Air Conditioning Guide has included considerable engineering data on radiant heating for several years and perhaps as a result of this there are now hundreds of such installations in the United States that are giving unusual satisfaction in comfort and economy. The trend in these installations seems to be toward the floor type heating panels.

It is my belief that with increased knowledge and experience the ceiling type panels will become more popular, for the following reasons:

1) Pipes embedded in the ground or concrete where any moisture is likely to occur, are subject to rapid exterior corrosion.

2) There is considerable heat loss into the ground.

3) Different types of floor coverings have a marked effect on the heat input, thus upsetting the heat balance in the structure, or requiring accurate knowledge by the designing engineer of the types of floor coverings to be used in each room before the installation is made. The many types of floor coverings available, or likely to become available, would require constant and extensive testing in order to enable the designing engineer properly to compute the heat input calculations.

4) On the other hand, the ceiling type of heating panels are subject to practically no ineffective heat loss. Exterior corrosion of the heating surface would not occur.

5) The rate of heat flow from the panels can be easily calculated.

6) Furniture would not interfere with the heat input or distribution, nor would it be subjected to constant temperatures above the room temperature.

From the standpoint of comfort no actual comparative tests seem to have been made, but I am inclined to believe that the ceiling panel system will prove the more satisfactory when ceiling heights are not abnormal.

The design of radiant heating systems seems to be surrounded with considerable mystery, and the fabrication and installation of the heating coils seems to present a very costly problem. These beliefs are only the result of lack of actual experience.

The Heating, Piping and Air Conditioning Contractors National Association is now preparing all necessary engineering data for all types of radiant heating systems. These data will be in simplified form and will be included in the book of standards distributed to HPACCNA members.

It is the hope that this information will remove much of the present sales resistance to radiant heating systems by placing contractors in a position to include radiant heating systems in their certified heating program.

It is my opinion that radiant heating systems will play a big part in postwar activities.—H. M. HART, president, L. H. Prentice Co.

HPAC's readers and editors will welcome your comment on articles or parts of articles published in these pages, and on other topics of interest to those concerned with design, installation, operation, and maintenance of heating, piping, and air conditioning systems in industrial plants, commercial, institutional, and public buildings . . . Address The Editor, Heating, Piping & Air Conditioning, 6 North Michigan Avenue, Chicago 2, Illinois.

Steam Heating Systems With Overhead Returns

THE EDITOR—

Sam Lewis' Page in the December 1943 HPAC comments strongly against the practice of forcing returns to an overhead return main.

The comments seem to stress objection to this practice in connection with vacuum returns. I am fearful that readers may interpret Mr. Lewis' remarks as confined to vacuum systems and find in his remarks an excuse for continuing to design high pressure systems with all overhead returns.

Mr. Lewis may intend to approve the use of overhead returns in high pressure systems, but it would be well to caution readers that such systems introduce many complications. Unless fully protected against accumulation of any condensate and noncondensable gases, convectors will not only "tend to hammer and click and complain" and drain specialties and pipe keep "eating out," but water hammer may be so great as to ruin the convector. Water hammer impulses must amount to internal pressures of 4000 or 5000 lb, which many operators do not seem to comprehend. —W. A. EVANS.

We Save Heating Dollars by Steam Trap Testing, Repair

THE EDITOR—

Referring to the article of the above title on p. 27 of the January 1944 HPAC, there are two suggestions I should like to make. Actually, in practice, it is not necessary to remove the entire steam trap from the line. The usual practice is to unscrew the cap and lift out the element only. The trap body can then be cleaned and testing of the element can be done by installing an extra or spare trap body on the test rig, fitting element after element into this one body for testing.

The practice of adding washers to elements which prove too short for tight closure may prove a temporary expedient. While the bellows in some elements may take an initial set which can be corrected in this manner, more often the failure to close is due to the element losing pressure through an insidious leak.

In that case, the adding of washers will prove only a temporary expedient. The element will continue to lose pressure and in a short time, the trap may leak again. To assure permanent repair, it is best to replace such elements with new ones in the first instance.—G. A. BINZ, Sarco Co., Inc.

UNDERFEED STOKERS ON 88% OF '43 CHICAGO JOBS

Permits issued by the city of Chicago smoke department for 1943 covering commercial and industrial fuel burning installations indicate that underfeed stoker equipment accounted for 88 per cent of the jobs where permits are necessary, according to the SMA. Permits were issued for 1322 underfeed stoker installations in commercial and industrial plants as against 1373 in 1942 and 1345 in 1941. In 1943, permits were issued for 44 commercial and industrial oil burners, in 1942, 153 oil burner permits were issued, and in 1941 there were 264 oil burner installations. In 1943 the city of Chicago issued permits for a total of 1496 fuel burning installations of all types and kinds, compared with 1634 total permits in 1942.

A message from the Government

issued jointly by
WAR PRODUCTION BOARD
SOLID FUELS ADMINISTRATION FOR WAR
PETROLEUM ADMINISTRATION FOR WAR

Help Conserve Fuel

Keep windows closed as much as possible—turn off radiators—or thermostats—to prevent waste.
Don't request heat outside of regular business hours.
Turn out lights when not required.
Cooperate with the management by accepting reduced standards of heating.
Use less hot water.

Saving FUEL Saves ★ TRANSPORTATION ★ MANPOWER ★ MATERIAL ★ EQUIPMENT

CONSERVE COAL OIL GAS FOR WAR

Measuring Moisture Content of Air

WE ARE interested in inquiring whether or not anybody has developed a satisfactory calorimeter for measuring the moisture content of air, says a reader.

Here's what we are after, he continues: On many moisture problems involving ventilation and the removal of moisture, it appears that the usual method of measuring the relative humidity and grains of moisture per pound in the effluent air is not entirely satisfactory. It also appears that it is occasionally possible to remove (with rather high velocities) some of the moisture in suspension rather than totally saturated in the air. If this is true, the total moisture leaving a building could not be measured by means of a sling psychrometer since that instrument would measure only the moisture that was absorbed by the air. If in addition any new particles of water were carried out as droplets in suspension, the sling psychrometer would make no record of it.

In order to investigate this condition we propose to use some form of separating device which preferably would allow the moisture which was absorbed to continue out in that state without interference by the separating device which preferably should separate out only the free moisture.

REPLY (by William Goodman, consulting engineer, the Trane Co., and member of HPAC's board of consulting and contributing editors): I know of no instrument that is available that would measure free moisture in suspension. However, I think it would be possible to develop an instrument to measure the quantity of free moisture in suspension. It would not be easy and would probably take skilled technique to develop an accurate instrument.

Briefly the principle is this. If the temperature of dry air is raised, a definite amount of heat which can be calculated is required to raise the temperature of the air. However, if free moisture is suspended in the air, a greater quantity of heat would be required to raise the temperature of the air the same number of degrees and, at the same time, evaporate the free moisture present in the air. If an instrument were available for measuring the amount of heat required to change the temperature of a sample of air a given amount, the excess heat added over the amount actually required for dry air could be used to compute the amount of free moisture suspended in the air.

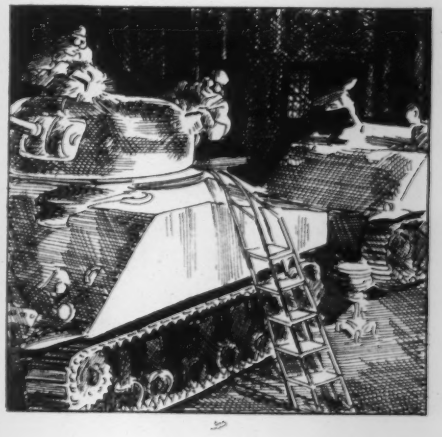
An instrument could probably be built of a small fan about the size

of a hair dryer connected to a short length of round pipe on the suction side. This fan would draw a sample of air through an electric heater installed in the suction pipe. A watt meter could be used to measure the amount of heat added to the air. Sensitive thermometers, calibrated to tenths of a degree perhaps, shielded from radiation and installed on each side of the heater, could be used to measure the temperature rise of the air. An orifice or pitot tube could be used to measure the air quantity. An instrument of this type properly constructed and insulated could be used, I think, to determine fairly accurately the amount of free moisture suspended in a sample of air.

The greatest difficulty would be in accurately measuring the dry bulb temperature entering the heater. If there is very much free moisture in the air, a few small droplets deposited on the bulb of the thermometer would cause an erroneous reading. Just how this can be avoided I do not see at the moment, but perhaps your reader with a little diligent research will be able to solve this phase of the problem.

REPLY (by M. K. Fahnestock, assistant director, engineering experiment station, University of Illinois): I know of no device that will give the total amount of moisture in air in which entrained moisture is present, other than chemical drying trains. These would not meet the requirements stipulated, namely: "In order to investigate this condition we propose to use some form of separating device which preferably would allow the moisture which was absorbed (really the moisture which is in the vapor state) to continue out in that state without interference by the separating device which preferably should separate out only the free moisture."

I am wondering if your correspondent really understands what he wants. What does he mean by the sentence: "It also appears that it is occasionally possible to remove (with rather high velocities) some of the moisture in suspension rather than totally saturated in the air"? He seems to intimate that the air which he is thinking of is only partially saturated and yet carries droplets of entrained moisture. I cannot envisage this state in any ordinary ventilating job. In all probability the air is usually saturated before any entrained moisture is present. Up to the point of saturation any sling psychrometer, aspirating type of psychrometer, or dew point humidity indicator would give the absolute humidity. If entrained moisture were present, I suppose it could be removed by eliminator plates and weighed, and the assumption made that the leaving air was saturated.



Downdraft Ventilation Scheme Solves Welding Shop Problem

Downdraft ventilation for welding booths is a new application for an established ventilating method. The application has been successfully tested and is believed to offer considerable merit for any plant engaged in manufacturing large welded assemblies. In plants welding small bench assemblies, an open steel grating could be used for a table top with downdraft ventilation through the table top in a similar application. Because of improved working conditions created by removing the welding smoke and by providing ventilation in hot weather, the cost advantages of this type of installation should prove favorable in many cases, says the author of this article, Hugh T. Monson, factory superintendent, The Euclid Road Machinery Company.

VENTILATING AN indoor welding department in which large assemblies are welded has long been a problem in the plant in which the writer is engaged. Various methods have been devised and used, but the best system seems to be the downdraft system herein described. This principle of downdraft ventilation has been used by another company for some time for the exhaustion of spray-laden air from paint booths.

A comparison of the usual overhead ventilation with downdraft ventilation is shown in Figs. 1 and 2. It should be noted in Fig. 2 how the welding smoke travels downward under the operator's helmet. Fig. 3 shows welding in another position in the downdraft booth.

The special downdraft arrangement consists of an enclosed chamber, or booth, with a pair of three-section folding doors on one end. It is open at the top to permit the entrance of free air.

The booth has a top opening of 12x24 ft or 288 sq ft. The air moved through this booth is 45,060 cfm, the lineal or facial velocity through the top opening being 156 fpm. This is somewhat in excess of the velocity used in paint spray booths, which runs about 125 to 135 fpm; the excess velocity was thought desirable because of the heat generated by the arc. It should be noted that working in moving air of this velocity does not seem to cause any objectionable drafts.

The tops of the side walls slope inward at an angle of 45 deg, and along these slanting panels there are openings to accommodate 12 light reflectors of a long range design which accommodate 300 to 500 watt light bulbs.

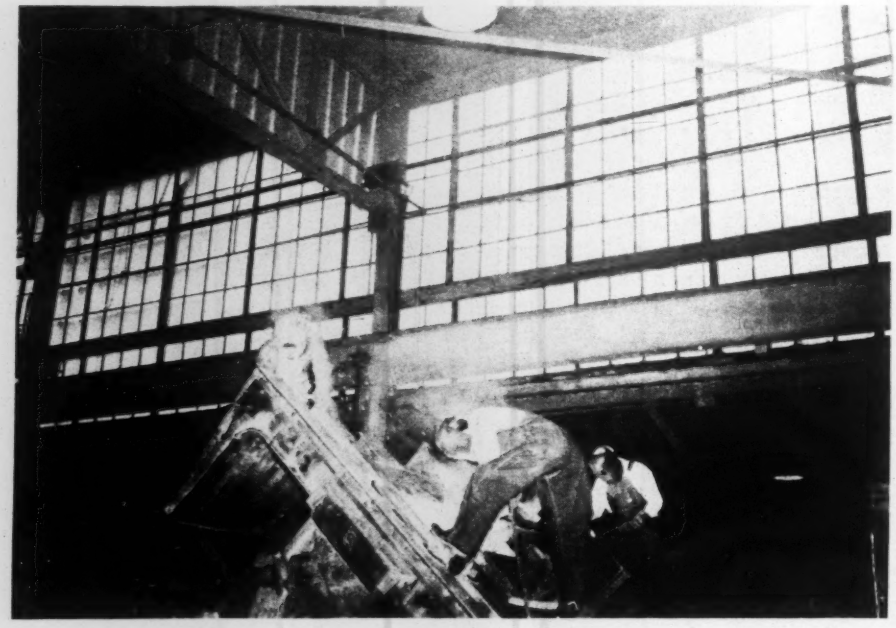
An area 16 ft wide by 24 ft long is provided for the road machinery assemblies to be welded in the booth. The 14 ft sides of this enclosed area are supported by six 4 in. pipes imbedded 2 ft in concrete. There are no cross braces on the top opening so that material may be handled into and out of the booth freely with an overhead traveling crane.

The air entering the booth at the top flows downward to the bottom of each of the side walls where it enters a 2 ft wide opening running the full length of the booth. Passing through this opening it enters a chamber 9 ft high by 2 ft wide. The air flows along this chamber to the rear of the booth, where it enters a 42 in. vertical stack through which it is exhausted to the outside atmosphere. There is a vertical stack for each side of the booth, each containing an exhaust fan which moves 22,530 cfm of air at ¼ in. static pressure. Each of these fans is driven through a V belt drive by a 3 hp, 1725 rpm motor specified for 220 volts, 60 cycle, 3 phase current.

Provision is made to anchor the stacks with guy wires and to drain rain water from the base of the stacks. There are automatic dampers in the stacks to prevent cold air from being drawn into the building by exhaust fans in other booths if the booth is not in operation. A roof flange is provided, and also a removable panel for access to the exhaust fan.

The sides and rear of the booth are constructed of 2 in. x 2 in. x ¼ in. angles welded into three separate frames for each side and the rear. To these frames are welded the same size angles for vertical reinforcement approximately every

Fig. 1—Conventional overhead smoke exhaust system



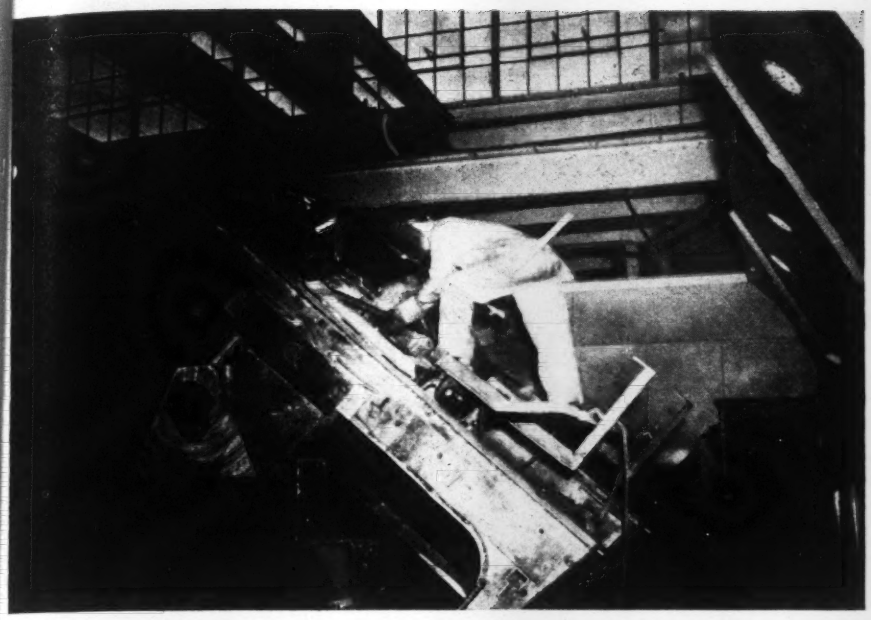


Fig. 2—Same operation as Fig. 1 in downdraft booth

3 ft along the length of the panel. Each frame is covered by 18 ga black steel sheet tack welded to the frame. Air chambers, doors, etc., are of similar construction—2 in. x 2 in. x ¼ in. angle framework covered by 18 ga sheet. Sides are welded to pipe columns and the remaining assembly is welded together.

The booth is painted dull black inside and out to minimize welding arc reflections.

Four booths are provided—two of them 16 ft wide and the other two 12 ft wide. The 12 ft booths are of the same construction as the 16 ft booths. They are provided with two 34 in. diameter propeller fans each moving 14,750 cfm of air at ¼ in. static pressure. Each fan is driven by a 2 hp, 1725 rpm motor. The top openings for these booths are 9 ft wide and the bottom openings at the base of each side panel are 18 in. high. The width of the side air chambers also is 18 in.

Four welding machines are provided in each booth. One man of the four operating in each booth is the booth foreman, responsible for the output of his booth because of the enclosure preventing the welding supervisor from watching operations. Large assemblies are welded in the two large booths; small parts and smaller assemblies are welded in the smaller booths.

Three unit heaters will be provided. One heater will operate on and off automatically with each of the two large welding booths. The third heater will operate automatically with either or both of the small booths. All intake air for these units is to be taken from outdoors.

Two factors make up the cost of operating these booths. First is electricity for fan motors and booth lights, which will amount to about $1266 annually for this installation.

Second is the cost of heating replacement air for that removed by the exhaust system. For this installation it was decided to replace half the air exhausted, for the following reasons:

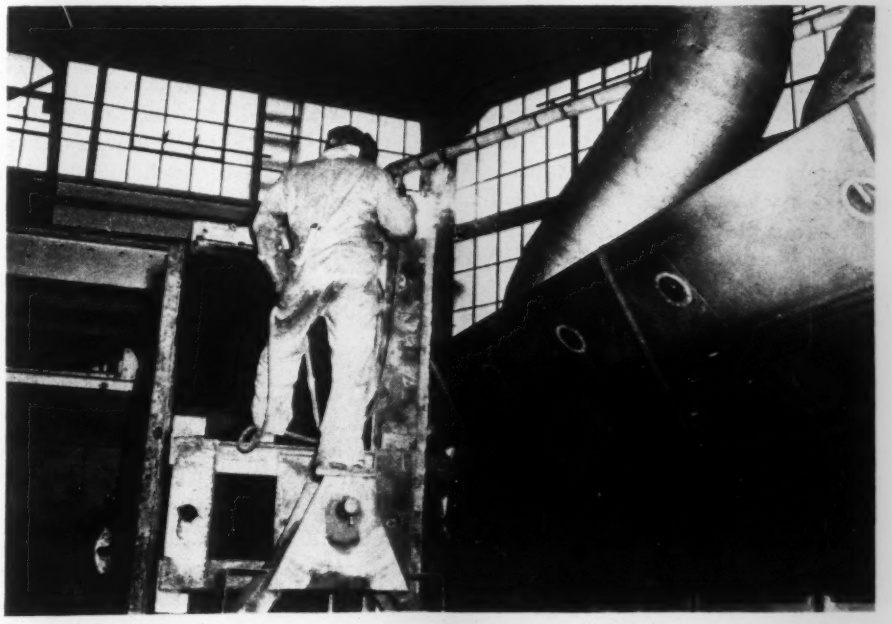
1) The area of the main plant from which the remaining 50 per cent of the heat is to be drawn is quite large. It comprises some 777,500 cu ft.

2) The construction of this plant is sheet metal and glass through which a considerable amount of heat is lost through openings. This heat will now be taken out through the exhaust system.

3) Temperatures through the main plant will be maintained more uniformly at the various levels above the floor because of the amount of air circulation that will be caused by the fans. At present, temperatures in excess of 100 F exist under the roof. The air circulation will maintain a temperature under the roof that is more nearly the 65 F working level temperature maintained in this part of the plant. This gives a reservoir from which heat may be drawn, much of which is now escaping through openings in the steel building at temperatures of 100 F. This is perhaps the most important consideration in arriving at the 50 per cent figure, for the heat that will normally go to building this temperature up and maintaining it can now be exhausted by the fans without notice.

Based on 100 hr per week operation and a 7½ month heating season, the cost of coal for operating these booths was figured to be about $1548.

Fig. 3—Another position in the downdraft booth



Equipment on Hand Adapted for Condenser Water Cooling; Will Pay Cost in One Year Savings

Water cooling equipment such as cooling towers and various types of spray coolers reduces the operating cost of air conditioning and refrigeration systems—particularly in localities where water rates are high and the temperature of the available water is also high. Wartime restrictions on the use of critical materials made it desirable on the job described here to utilize equipment already on hand for cooling condenser water. N. R. Bernz—consulting engineer and member of HPAC's board of consulting and contributing editors—tells how an evaporative cooler is used for cooling the condenser water for a 35 ton conditioning system.

WARTIME RESTRICTIONS on critical materials required for air conditioning and refrigeration systems make it necessary for many enterprises to get along for the duration with whatever equipment they have on hand. Repairing, revamping, substituting, and improvising become the orders of the day. Restrictions on the use of municipal water supplies for condensing purposes in air conditioning and refrigerating systems in many localities add to these difficulties.

In connection with the latter problem, the possibilities of renovating and using discarded water spray apparatus—air washers, humidifiers, evaporative coolers, etc.—should not be overlooked. Frequently such equipment can be overhauled and used for condenser water cooling.

When the writer was approached on such a problem recently, by the owner of an air conditioning system, an inventory was first made of available second hand equipment in his various departments (such as fans, motors, pumps, and other spare parts) that might possibly be assembled into a spray unit for the purpose of cooling the condenser water. A discarded evaporative cooler, consisting of a centrifugal blower, a small water tank, a set of spray nozzles, and a water circulating pump, was right in line with our requirements. The pump was too small, however, to be of any value in connection with the particular problem; the spray chamber also had to be redesigned with a different nozzle arrangement in order to obtain a higher efficiency of the thermal exchange. A spare pump of the turbine type with a 7½ hp motor, previously used in another process, was overhauled and incorporated into the spray unit.

The air conditioning machinery involved is in the basement of the building and since the only available space for the water cooling equipment is on the roof, three floors above, a well balanced design would have necessitated a considerable amount of new water piping. In order to conserve critical materials, however, it was decided to use the old piping which originally served the evaporative cooler. While probably oversized in the original system, these pipes were somewhat small for the new water volume, taking the power cost of pumping into consideration. However, present scarcity of materials warrants a certain waste in operating efficiency; by sacrificing a bit in operating economy in this particular case, the water piping proved to be of sufficient capacity to serve the purpose.

Design of Water Cooling System

The refrigeration is produced by one 20 and one 15 ton "Freon 12" compressors, cross connected and installed in conjunction with an extended surface coil and a 10,000 cfm centrifugal blower. The condensing units operate on the basis of 40 F and 100 F suction and condenser temperatures respectively, requiring a condenser water volume of approximately 1.3 gpm per ton, with 70 F water.

The redesign of the evaporative cooler to serve as a condenser water cooling unit was based on 75 F wet bulb temperature of the outdoor air, an "approach" of 5 F, and a rise of 10 F in the water going through the condensers, resulting in 3 gpm per ton or a total water volume of 105 gpm.

Allowing 15 psi pressure drop through the condensers and providing 30 psi pressure on the spray nozzles, a total pumping head of approximately 150 ft was calculated. The available turbine pump was of ample capacity to supply the required water volume. Owing to some uncertain factors in calculating the pump head, and in view of the power characteristics of the turbine type of pump as compared to the strictly centrifugal type, it was necessary to regulate the head by means of a valve in a bypass rather than directly in the discharge line, to prevent overloading. The pump head is controlled by means of bypass valve "A" and gage "B," Fig. 1.

In order to insure as efficient operation as possible, it was decided to utilize the exhaust air from the conditioned space, together with outdoor air, in the water cooling process. The quantity of outside air supplied in this particular air conditioning system represents a considerable percentage of the total air volume; a corresponding amount must naturally be exhausted or eliminated through leakage.

Although the amount of exhaust air is of necessity small as compared with the total air volume handled in a spray cooler of this type, the advantage of utilizing air with the lowest possible thermal energy, before it is discharged to outdoor atmosphere, can readily be seen. In this particular instance, the difference in total heat between outdoor air and the exhaust air may amount to 6 or 7 Btu per lb of air under heavy load conditions, when conservation is most needed; this is no small item and its conservation is undoubtedly reflected in the

performance values recorded below. Since the water cooling unit is on the roof immediately over the conditioned space, it is relatively simple and inexpensive to convey the exhaust air to the cooler by means of a short duct connection, as shown in Fig. 2.

Performance of the System

As the water cooling system was completed toward the end of the cooling season, complete test data could not be obtained; it was possible to secure psychrometric readings on two different occasions only. These are illuminating, however, with respect to performance.

On the day of the first test, the outdoor dry and wet bulb temperatures were 83 F and 78 F; the air after passing through the spray chamber was practically saturated at a temperature of 80 F. The condenser water entering the cooling unit at 92 F was cooled to 82 F.

On the occasion of the second test, the outdoor temperatures were 84 F dry bulb and 76 F wet bulb. The air leaving the spray chamber gave dry and wet bulb readings of 79 F and 78 F, respectively. The condenser water temperature was lowered from 88 F to 80 F as it passed through the cooler.

In both these cases the air passing through the cooler was saturated, or nearly so, at a temperature only 2 F above the temperature of adiabatic saturation, and the condenser water was cooled to within 4 F of this temperature. The first case represents 71 per cent and the latter 66⅔ per cent cooling efficiency, which compare favorably with good cooling tower performance.

The use of water cooling equipment (cooling towers and various types of spray coolers) reduces the operating cost of air conditioning and refrigeration systems. This is particularly so in localities with high water rates and where the temperature of the water available for condensing is also high. Under certain conditions the water may be so warm that abnormally large volumes are necessary to keep the condenser pressures within economical limits. In the above air conditioning system the annual cost of city water for condensing purposes would run approximately $800 to $900. It is estimated the cost of the water cooling system will be recovered in practically one season.

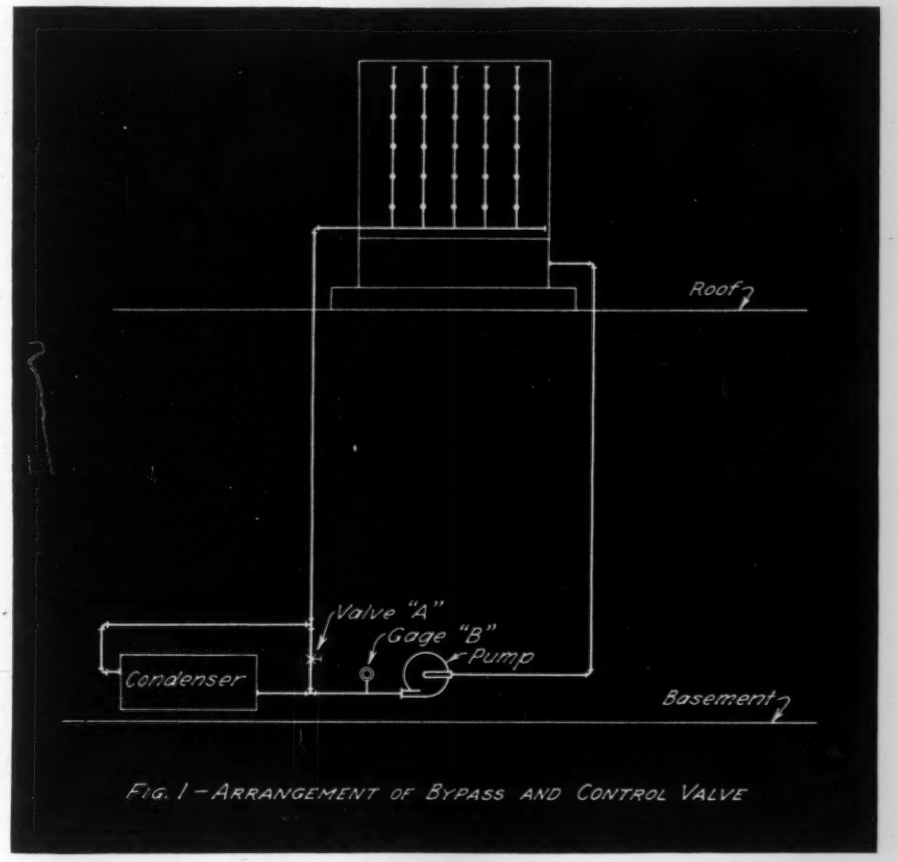


FIG. 1—ARRANGEMENT OF BYPASS AND CONTROL VALVE

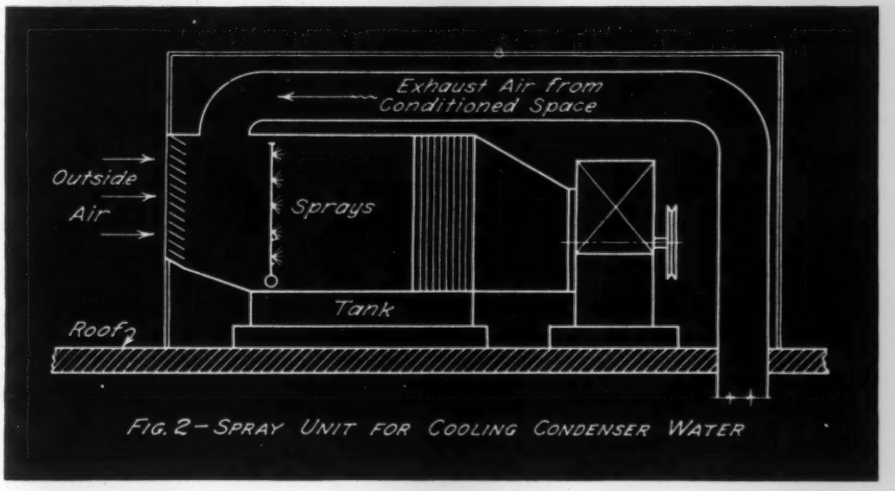


FIG. 2—SPRAY UNIT FOR COOLING CONDENSER WATER

In discussing the above subject, data have been presented from an actual spray cooler installation, and some thoughts have been injected on the design and performance of such equipment. The primary object of this article, however, is to indicate the possibilities of utilizing apparatus and machine parts discarded before the war emergency. By intelligent application of such machinery, equipment may be improvised which will enable us to operate our various industries until such times when up-to-date equipment will again be plentiful on the American market.

BUY MORE WAR BONDS NOW

MEASURING the FLOW of FLUIDS

SOME OF those who find it necessary to meter the flow of fluids may find it difficult on occasion to obtain manometers and orifices. As a consequence of the war, even those with fairly high priorities sometimes may be forced to wait for a considerable period for the delivery of equipment; those whose priority ratings are low or who have no right to obtain a priority at all may find it virtually impossible to obtain equipment. The instructions in this article may offer a solution to such difficulties; they also serve to indicate some of the considerations involved in the design and construction of commercially-available flow measuring equipment.

Single Tube Manometer

A single tube manometer of the type illustrated in Fig. 11 requires more work to make than a U tube manometer and more mercury for filling. On the other hand, the single tube manometer is easier to manipulate and to read accurately. The height of a single pulsating column of mercury can be read more quickly and accurately than the heights of the two separate columns in a U tube manometer.

As shown in Fig. 11, mercury is contained in a large cup at the bottom of the instrument. As the upstream pressure is applied above the surface of the mercury in the cup, a small amount of mercury is forced out and up into the glass tube. Because of the large cross-sectional area of the cup, the level of the mercury in it changes very little even though the mercury level rises appreciably in the small diameter glass tube.

As is shown in Fig. 11, the glass tubing is connected into $\frac{1}{8}$ in. tees at the top and bottom by means of compression fittings of the type described in the January HPAC in connection with the U tube manometer. The open end of the glass tubing should always extend beyond the shoulder inside the steel compression connector. This applies equally to both the upper fitting and to the lower one, if a lower one is used. The mercury cup, at the lower end, can be made of a section of 2 in. pipe about $1\frac{1}{4}$ in. long by welding steel plates to the open ends. The cup is set with the plates horizontal. The bottom of the mercury cup should be flush with or slightly above the top of the compression nut at the bottom of the glass tube.

A surge chamber is provided at the top of the manometer, as shown in Fig. 11. This chamber is also made of 2 in. steel pipe about 2 in. wide by welding flat steel plates over the open ends. The surge chamber is set with its flat sides vertical. A bypass from the bottom of the surge chamber connects to the top of the mercury cup below. The bypass is made of a piece of $\frac{3}{8}$ in. steel tube. A $\frac{1}{4}$ in. hole is drilled in the bottom of the surge chamber before welding the $\frac{3}{8}$ in. tube in place. The valve marked "2" in this bypass must be all steel; a satisfactory type for this purpose is a steel bar stock valve. If mercury is blown over from the mercury column into the upper chamber, it can be returned to the lower cup by opening the steel bypass valve "2." The valve should be so installed that mercury will drain through it without being trapped. Inspection of the valve interior will at once make apparent how it should be installed so that it will drain without trapping any of the mercury. The connection from the downstream tap of the orifice is made into the top of the surge chamber. A tee is used on the top of which a vent valve is connected.

A scale can be made in the same

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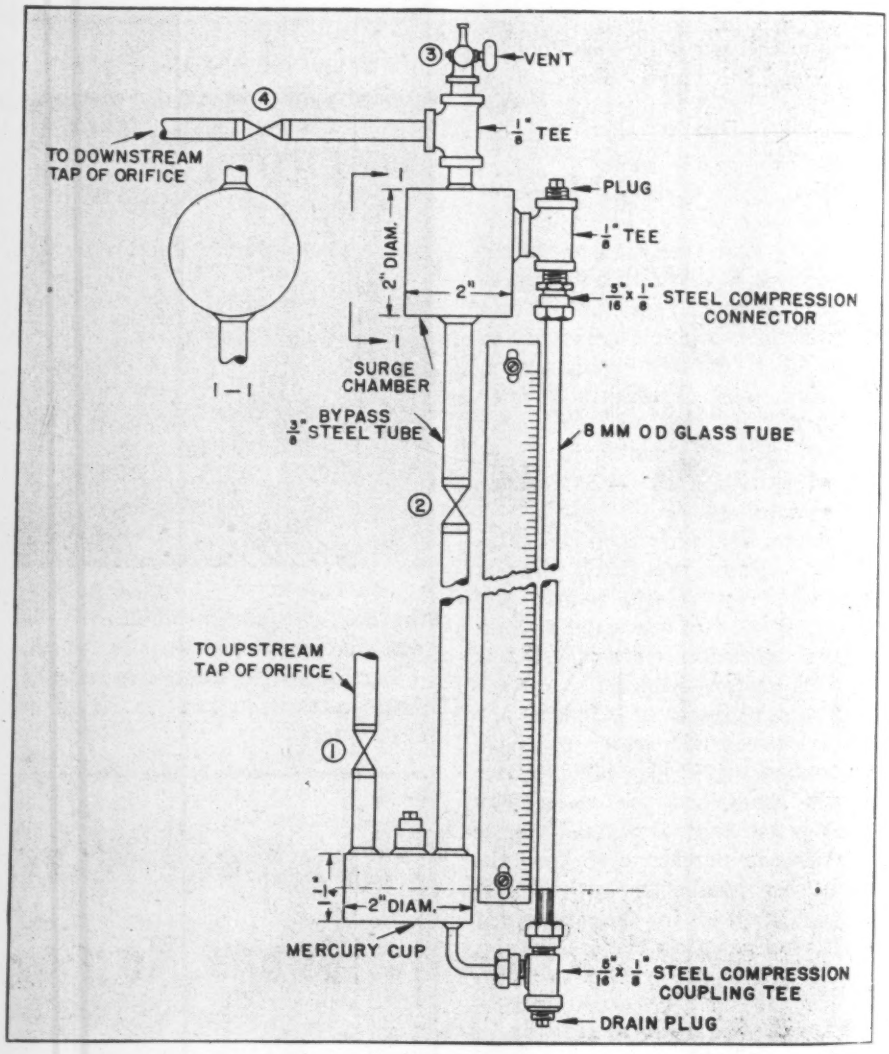


Fig. 11—Details of a single tube manometer

manner as the scale described last month for the U tube manometer. However, the scale must be so installed that it can be moved vertically about ¾ in. The zero of the scale must be set to the mercury meniscus in the glass tubing. For this purpose slots should be provided at the top and bottom of the scale. Loosening the screws permits the scale to be slid up or down to the correct position, after which the screws can again be tightened.

As the mercury column goes up in the glass tube, it is apparent that the mercury inside the cup must drop. However, the zero of the scale is set to the level of the mercury in the glass tube, and this level is the same as the level of the mercury in the cup *when the pressures are equalized.* Hence, the scale measures the rise of the mercury in the glass tube. It does not measure the additional drop of the mercury in the cup. The actual head is, of course, the difference between the mercury level in the cup and the mercury level in the tube. However, with a cup of 2 in. diameter and an 8 mm OD glass tube, the correction is negligible.

For those who wish to make the correction, however, the height of the mercury column as read on the scale should be multiplied by 1.013 to obtain the true height of the mercury column. This correction is true only for a tube of 6 mm inside diameter and a mercury cup made of 2 in. steel pipe. The multiplier for a cup and tube of any diameter can be figured by means of the following formula:

$$\text{Multiplier} = 1+\left(\frac{D_t}{D_c}\right)^2 \quad \ldots [10]$$

where D_c = inside diameter of mercury cup at bottom of single tube manometer, in., and D_t = inside diameter of glass manometer tube, in.

Another method of making this correction is to space the divisions on the scale in such a manner as to compensate automatically for the correction. If the correction is 1.013, the correction can be automatically made by so drawing the scale that each division which is marked 1 in. is only 0.987 in. long $(1 \div 1.013)$, instead of 1 in. By calling each space of 0.987 in. one inch and dividing it into tenths, the scale reading will give the actual difference in head between the level of the mercury in the glass tube and the level of the mercury in the cup. This scale should also, of course, have its zero adjusted to the level of the mercury in the cup when the pressures on both sides of the manometer are equalized.

Other details of construction will be apparent from an examination of Fig. 11 and from a reading of the section on the U tube manometer, which appeared last month.

Knowledge of the quantity of fluid flowing through a pipe line is essential or desirable in much industrial and engineering work. Orifices and manometers are invaluable for measuring flow rates both on the job and in the laboratory; it has therefore been the purpose of the articles of which this is the seventh and last to present the data necessary for the selection and use of such flow-measuring equipment . . . The author, William Goodman, consulting engineer, the Trane Co., and a member of HPAC's board of consulting and contributing editors, discusses this month the construction of a single tube manometer and its manipulation.

After the manometer has been thoroughly cleaned, it should be installed with valves "1" and "4" closed and valves "2" and "3" open. The manometer can be filled with mercury through the mercury fill plug in the lower cup. For the manometer described, with a tube about 36 in. long, about 1½ to 1¾ lb of mercury will be required. Watch the mercury level in the glass tube when filling; the mercury level should be about ¾ in. above the inside bottom of the cup. For large pressure differences, the mercury level in the cup will fall about ½ in., leaving only about ¼ in. above the bottom, which must never be uncovered or incorrect readings will be obtained.

Manipulating the Single Tube Manometer

When the mercury first rises in the glass tube, it may not be in a solid column but may have air or liquid between the mercury pellets. In a single tube manometer the pellets can be broken up and a solid mercury column formed easily. Valve "1" should be cracked open, valves "2" and "3" should be wide open, and valve "4" closed. Slowly raise the mercury almost to the top by closing valve "2." Now open valve "2" as quickly as possible. The sudden drop of the mercury column will usually break up the mercury pellets and force them together. Repeat the operation again if necessary. Particularly obstinate pellets of mercury near the top of the column can be driven over into the surge chamber and returned to the lower cup by opening valve "2."

After the cup has been filled with mercury, the connections between the orifice and the manometer must first be vented of air. First make sure that bypass valve "2" is wide open and vent valve "3" is just cracked open. Next crack valve "1" and fill the manometer with the fluid being metered. The air from the upstream connection will be vented through bypass valve "2" and out through vent valve "3." Next close valve "1" and crack valve "4" open, thus venting the downstream connection. After the downstream connection has been vented, close valve "4."

If the manometer is to operate properly, there must be no air in the upper part of the glass tube. Air in the upper part of the glass tube can be eliminated as follows: Again be sure that valve "2" is wide open, valves "1" and "3" just cracked open, and valve "4" is closed. Now raise the mercury column in the glass tube by slowly turning valve "2" toward the closed position. Stop operating valve "2" when the mercury column reaches almost to the top of the glass tube. Next crack valve "4" slightly open. This may cause the mercury column to drop. If it does, again turn valve "2" toward the closed position until the mercury is again almost to the top. Next close valve "3" and slowly open valve "2" wide. The mercury column will drop and the glass tube will fill with fluid through valve "4." Close valves "1" and "4." The manometer is now ready for use.

To use the manometer, make sure that valves "2" and "3" are wide open and that valves "1" and "4"

are closed. Adjust the zero of the scale to the level of the mercury in the glass tube. Next crack valves "1" and "4" open slightly. Then close vent valve "3." Finally, close valve "2" slowly, keeping your eye on the rising column of mercury in the glass tube. The mercury will rise more and more slowly as the height of the column increases. Finally close valve "2." The height of the mercury column can now be read. This height is used for computing the flow through the orifice.

During operation of the manometer, if a sudden surge of pressure or an excessive flow through the orifice should force all of the mercury into the surge chamber, opening valve "2" will permit the mercury to drain back into the lower cup. A great advantage of the single tube manometer, aside from the ease and accuracy of reading the height of the mercury column, is the ease with which the mercury pellets can be broken up to form a solid column and the rapidity with which mercury can be returned to the lower cup after it has been blown into the surge chamber by excess pressure.

Auxiliary Electric Heating Improves Diesel Operation

DIESEL ENGINES work best at approximately full load, as only under these conditions is the internal heat high enough to insure a proper combustion of the oil fuel. It is often difficult to start up a cold diesel using heavy oil unless an auxiliary supply of more volatile fuel is used during the warming up period, but this added complication is undesirable.

There are many installations where load conditions vary greatly, such as for diesels on large auto trucks, switching locomotives, and for auxiliary power on motor ships. In the latter case, when a ship is at sea, the steering engines and other auxiliaries require considerable power. When handling cargo at ports, the hoisting engines use power intermittently. At night, power is used for lighting and there are many other variations in power demand. This situation is very unfavorable for high speed diesel engines driving electric dynamos to produce power for auxiliaries.

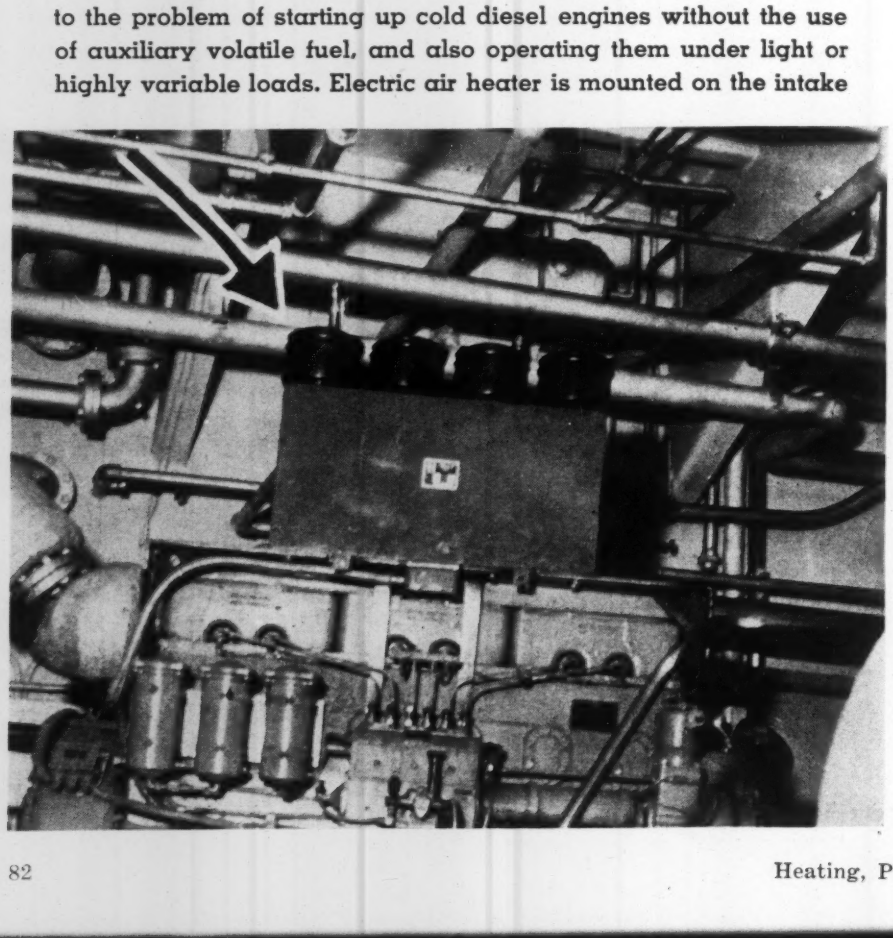
A simple solution has been found for starting up cold diesel engines without the use of auxiliary volatile fuel and also for operating engines under light or highly variable loads. This solution is to introduce electric heat in the air intake to the supercharger of the engine and control this heat automatically according to the load on the engine. When the engine is operating at small load and does not produce enough internal heat, the intake air is electrically heated before it enters the engine and this initial heat is multiplied by the compression so that a satisfactory operating temperature is obtained in the firing chambers.

Many applications have been made for both large and small engines. The illustration shows a large diesel auxiliary engine which drives an electric generator on a motor ship. The arrow points to the electric air heater mounted on the intake at the top of the engine cylinders. On the heater are four intake filters through which air is drawn by the engine suction. The electric heat is supplied by power from the generator driven by the engine and is controlled by the load being carried on the engine. Heat is used only when the engine load is too small to produce a proper internal firing temperature in the combustion chambers.

This installation overcame the previous poor engine performance which had resulted in foul cylinders, sticking valves, and poor efficiency as measured by fuel consumption.

Each installation must be carefully designed but this auxiliary heat method offers many opportunities to secure better operation of diesel engines. Where engines do not drive generators, the necessary electric power for heating can be taken from other available power lines, or for starting up cold engines the power can be taken from auxiliary batteries.

Lee P. Hynes, consulting engineer and member of HPAC's board of consulting and contributing editors, explains a simple solution to the problem of starting up cold diesel engines without the use of auxiliary volatile fuel, and also operating them under light or highly variable loads. Electric air heater is mounted on the intake



Refrigerated Firing Range Tests New Aircraft Cannon

NEW HEAVY calibre aircraft cannon soon will pump their shells over the world's shortest firing range—a distance of 22 ft—as engineers at an Army air forces proving ground test the effectiveness of the big guns in a made-made stratosphere 70 F below zero. The firing range comprises twin steel vacuum chambers where temperature and air pressure will duplicate the stratosphere nine miles above the earth. In this atmosphere, shells will leave the muzzles of the guns, travel the length of the 22 ft range, and plow into 20 tons of sand with the force of approximately 3,600,000 ft-lb of energy, according to John Bergdoll, chief of the York Corp. laboratories.

"In the contest to equip high altitude bombers with bigger and bigger calibre cannon and machine guns, aircraft designers must know more about the effect that lack of oxygen and subzero weather have on the detonation and the speed of projectiles," Mr. Bergdoll explained. "With this newest application of the stratosphere chamber, they can study at close range conditions which ordinarily could be observed only in actual combat.

140 F Temperature Drop

"A modern stratosphere bomber rising from sea level to 40,000 ft endures a 140 deg drop in temperature in a few minutes. This causes a terrific shock contraction of all metals, many of which will contract at different ratios. It is important to know how this affects firing mechanism and gun barrels. Likewise," Mr. Bergdoll added, "at 40,000 ft the atmosphere approaches a near vacuum and makes possible greater speed for a projectile because of less resistance from the weight of air. The effect of low moisture content on delicate firing mechanisms and the greater concussion produced by big guns in rarefied air are among other questions which can now be studied."

Two steel cylinders and a third concrete sand trap will make up the stratosphere firing range, the whole covering a distance of only 50 ft. The first compartment will be a stratosphere chamber similar to that used to test pilots and plane equipment. In it will be mounted the gun to be tested with its barrel projecting forward through the front end of the chamber and into a concussion chamber. With the

muzzle of the gun just projecting into the concussion chamber, the shells will be fired across the 22 ft space and into another porthole at the forward end of the chamber. In back of this porthole will be the sand trap chamber of reinforced concrete with its backstop of 20 tons of sand.

Even the shells from a 75 mm cannon fired through the frigid artificial stratosphere can be stopped after they have traveled the length of the range despite the fact that they have energy equivalent to lifting an object weighing 1800 tons a distance of 1 ft. Actually such shells would plow into the sand bank for a distance of 10 ft with enough pushing power theoretically to send a 1 lb projectile 680 miles. At the present time, the shortest known range for heavy calibre guns is 300 ft.

Partial Vacuum of 2.2 Psi

Two men equipped with oxygen masks will enter the main stratochamber to operate the big guns. For each maximum test, temperature will be dropped from 70 F above to 70 F below zero in 12 min while air pressure is reduced to a partial vacuum of 2.2 psi. In the concussion chamber ahead into which the muzzles of the guns project, temperature will be maintained at 67 F below zero. In this chamber, cylindrical steel walls must be constructed to absorb the shock of a concussion bursting pressure of 100 lb for every square inch of surface.

A period of 12 hr is required to prepare both the main stratochamber and concussion chamber for 1 hr of testing. During this time, the refrigerant is circulated through coils in the upper portion of the chambers until the temperature drops below minus 70 F. Just before each test, this frigid air in the chambers will be warmed quickly by electric heaters to a normal 70 F above to simulate the start of a stratosphere flight. When the chambers are loaded and sealed, the warm air will be withdrawn and cold air together with the refrigeration built up in the walls will drop the temperature all the way back to 70 F below in 12 min.

The modern stratochamber with temperature and air pressure control was first developed for an institute in Canada in 1939. Since then, more than 30 have been built for aircraft plants, government laboratories, proving grounds, and universities. Their principal use has been to test stratosphere pilots and their equipment for high flying endurance. Largest application of this stratochamber technique is a huge hermetically sealed wind tunnel which will develop a 700 mph man-made gale refrigerated to 70 F below at an air pressure equal to 42,000 ft elevation.

Design provides for dropping test temperature from 70 degrees above zero to 70 degrees below zero in 12 minutes

Heating and Ventilating at a Navy Torpedo Plant

THE OBSERVING visitor to the Amertorp Corp. U. S. Naval Ordnance torpedo plant, Forest Park, Ill., will notice upon entering the beautiful glass block lobby that there is an abundance of clean, warm air. The entire front is glass block and doorway, which affords very little space to install any heating units. Just above the revolving doorway there is a horizontal blower type heater concealed in a furred space, which draws air across a steam coil, then discharges it down across the doorway, blanketing the entire front of the room through a specially designed grille. This unit is automatically controlled by a room thermostat in the lobby through a pushbutton starter. Normal heating of the lobby is by means of two warm air grilles connected by ductwork to the office building ventilating system. A booster heater within the duct connection maintains the area at the required temperature under normal conditions.

Six Heating Zones

The office building is heated by means of convector type units constructed of steel coils in suitable cabinets. Low pressure steam supplies the convectors, which are divided into six separate zones, each automatically controlled for conservation of steam as well as proper space temperatures. The steam main serving the building runs across the basement ceiling to either end of the building where it branches each way to take care of north and south and east and west zones. At the beginning of these branches, thermostatically controlled valves regulate the amount of steam required to keep the basement, first, and second floors at suitable temperatures.

The steam main in the basement comes from behind a wall and stepping through a doorway to the place from which this main seems to be coming, the visitor finds himself standing in a tiny room with another door on the opposite side. This is nothing more than an air lock to protect walls and doorway to the fan room just beyond. Within this fan room the pressure reducing valve station is situated, serving requirements of this separate building. This station comprises a reducing valve and auxiliary equipment and is supplied by means of a high pressure line which runs up through the ceiling at a column nearby. Low pressure branches then leave the station to supply blast coils and the general heating system.

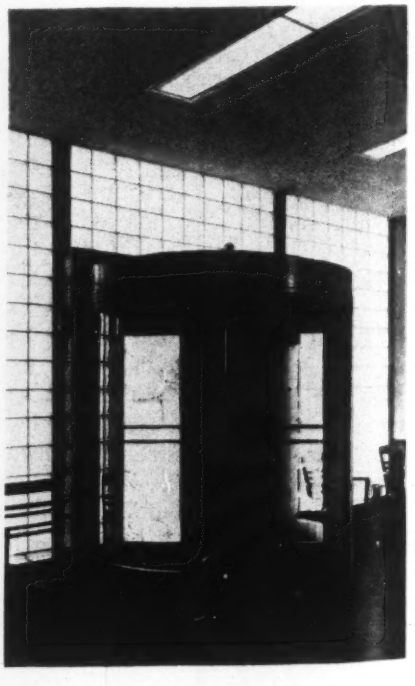
The room otherwise houses a large warm air heating plant, designed to supply warm air to the entire office section. Air enters the intake chamber, passes through automatic oil filters to a double width fan from whence it is zoned, heated and transmitted to that part of the building for which it is intended. Return air shafts and outlets terminate in a separate plenum in the fan room from which air is exhausted and discharged to the atmosphere or returned to the warm air heating system as required or desired.

In each zone, temperature is controlled by means of motor operated bypass dampers.

The Piping Layout

In one corner of the fan room, below the main zone shaft, is a duplex condensate pumping unit. The discharge from this unit fol-

Starting at the glass block entrance lobby, which is heated by means of a horizontal blower type unit concealed in a furred space, Robert V. Mehaffey, mechanical engineer, Albert Kahn Associated Architects and Engineers, Inc., takes us through the Amertorp Corp. U. S. Naval Ordnance torpedo plant at Forest Park, Ill., ending up with the boiler house, where all the steam for space heating and process work is generated. . . . The office building is heated by convector units made of steel coils in suitable cabinets, there being six zones for steam conservation and good control. . . . In the main manufacturing area, there are 95 unit heaters, 15 winter supply units, 60 summer supply units, and 75 exhaust units. . . . A separate wing for some very special work is served by central warm air plants. . . . Warm air systems in three separate fan rooms serve the locker rooms, recreation rooms, toilets, and kitchen and cafeteria. . . . There is also a great deal of blow pipe and dust collection equipment for the manufacturing departments



lows up the same column as the high pressure main. Tracing these two lines to the manufacturing building, one views—high in the truss work—a network of various types of heating and ventilating units and piping. In order to understand more easily the system, let us continue to follow the pump discharge line and high pressure main, both of which connect to other piping along the route.

These lines run straight across the center of the manufacturing building to the opposite side and drop down to a tunnel below. At this far side, however, another distributing station is situated—this one being larger and equipped with an additional reducing valve for minimum and maximum loads. From this station, 30 psi steam is supplied the building. The 30 psi line parallels those previously mentioned across the center of the building. Branch lines take off the main at each bay, running each way lengthwise of the structure and serving units all along the route.

Process Heat Must Be Considered

In designing such a network of piping it is necessary to determine the conditions employed in actual manufacturing production; the heat content of equipment, the industrial exhaust from tanks or sanding and grinding equipment, and a number of other incidental features involved in manufacture. Systems such as are used in this structure afford a flexibility that usually proves to be satisfactory and economical for all conditions. The primary purpose is to provide for variable conditions at different times, all in accordance with the process of manufacture and outside atmospheric conditions.

For example, in a definite location in the building, process requires a certain amount of exhaust ventilation. When in operation it is possible to replace immediately the exhausted air with tempered air from outdoors. Should the process require only a part of the full amount of exhaust, so too can the outdoor air be throttled to replace only a like amount and the balance as handled by the supply unit can be automatically recirculated, at the same time maintaining suitable temperatures for working conditions. This condition is handled by means of winter supply units.

In summer or mild weather, summer supply units are placed in operation to provide for the same conditions, as well as to furnish ample air supply to replace air exhausted from the structure, keeping the building at least as comfortable and as clear as outdoors. Should conditions warrant additional exhaust, certain of these exhaust units in the roof may be operated at any time, thereby vitiating all smoke or fumes created by process.

245 Units Used

Unit heaters, properly spaced also in the truss space, serve to cover the normal heating load and each of these is thermostatically controlled, so the pattern formed by unit heaters, winter supply units, summer supply units, and exhaust units provides for almost any condition that may exist within the building. Ninety-five unit heaters, ranging in capacity from 260,000 to 450,000 Btu together with 15 winter air supply units handling from 7500 to 20,000 cfm, 60 summer air supply units handling 10,000 cfm each, and 75 exhaust units each handling 10,000 cfm complete the layout. The heating and ventilating installation is largely responsible for the good production records made by this plant, because

The convector units for heating the office areas are divided into six zones

of the conditions of cleanliness, comfort, and sanitation afforded to those who labor over lathe and laboratory table.

Separate Wing Has Provisions for Dehumidifying

At the back of this plant is a separate wing, part of which is used for some very special work. This space is provided with separate central warm air heating plants designed to distribute filtered and tempered air across each area. Fans and auxiliary equipment are on the roof above. One fan unit supplies one of the rooms and laboratory. Zones control the temperatures in different areas automatically with steam coils in each zone. Air is returned and exhausted from floor

Fuel Conservation Reminders

(From Scotty-Grams, a bulletin issued to operating personnel of the Chicago Board of Education by John Howatt, chief engineer, and member of HPAC's board of consulting and contributing editors)

Dampers should be closed while cleaning fires to prevent air from rushing in and damaging heated brick work and cooling off boiler and furnace by excessive air.

Good controlled draft is very important. Check dampers, breeching, and stack to see that all are in good condition so control may be had.

Better control of uptake dampers can be had by using sash chains instead of the old fashioned rods to hold them in intermediate positions.

It is estimated that nearly one-third of the heat value of coal used in the United States passes away through the stacks.

Close siphon roof vents in gym and basements during heating season to heat seal the building.

"Lazy" thermostats waste fuel; a checkup of filter gaskets is advised.

The installation of a hot water thermometer on the condensate return from the heating system will serve as a guide for better operation.

Conservation does not aim at the reduction of fuel usefully burned but rather at the elimination of waste. Conservation implies use without abuse.

In the absence of a static pressure regulator, equalize pressure in tempering and blast chamber by hand control of volume dampers.

Close off all openings around inside downspouts or other pipes where they occur at basement ceilings or at attic floors.

Ninety-five unit heaters, 15 winter supply units, 60 summer supply units, and 75 exhaust units serve the main manufacturing area of the big plant

trenches by means of two separate fans; one is for exhaust alone and another for exhaust or return to the supply system. Automatic controls maintain the incoming air at a predetermined temperature by throttling dampers to permit required volumes of outside air and return air.

A like system serves the other room, with provisions in each for dehumidifying and air processing, which has now been installed.

Within this fan room is another reducing station reducing the pressure to that suitable for proper operating conditions.

The north portion of the manufacturing building houses locker rooms, recreation rooms, toilets, and the kitchen and cafeteria—all in the basement area. All are heated and ventilated by means of warm air systems which are in three separate fan rooms, one at either end of the building and the third in the center. From these fan rooms, systems of duct work serve each group of rooms, forming a systematic network of supply and exhaust ducts to permit conditions of comfort within these otherwise totally enclosed areas.

In each of the three fan rooms, steam is supplied at high pressure, reduced through control stations and thence connected to heating coils in the supply units. Each fan room also has in one corner a duplex type condensate pump and receiver which collects the condensate from the blast systems as well as the heating system in the manufacturing area above and other equipment around the plant which is supplied with steam. The discharge from each pump is connected into a common main and returned to the boiler house.

In all of these warm air and exhaust systems, careful distribution of air is accomplished by the use of directional flow grilles, permitting a proper movement and blanket of warm, clean air covering the various areas. A thorough selection of grilles for this project involved proper throw with reference to the distance over which the air was to be carried in a satisfactory direction.

Blow Pipe and Dust Collecting Equipment

On traveling through the manufacturing area one notices the neatness and efficiency with which blow pipe work and dust collecting equipment is installed in various departments around the plant.

Propeller grinding machines are set up in units of four. From each side of each of these four machines an exhaust duct connects to the specially designed hoods around the grinding wheels and from there to a common trunk duct which carries overhead to separate dust collectors for each such group.

From each collector, a main duct connects to a fan suspended from the roof structure, discharging to the atmosphere. At certain machines separate dust collecting units are provided and the air is discharged into the room through secondary cleaners.

A similar dust collecting system serves the tool grinding department while separate groups of hoods over

various assembly benches connect to fan units and discharge to the atmosphere, keeping the air free of dust particles and obnoxious fumes.

Numerous blowers, together with duct systems and hoods, serve such processes as welding, heat treating, plating, grinding, and wood working departments. Each has its own peculiarities. Some exhaust poisonous fumes, some harmful dust particles, some moisture particles which are extracted before entering the blower; some exhaust dust which is extracted and the air thoroughly cleansed and returned to the room area or to an adjacent area which may require circulation.

The Boiler House

Beyond and south of the main group of buildings is the boiler house. It is here that all of the steam is generated for process and space heating.

Three multiple drum bent tube boilers, two of a capacity for actual evaporation of 60,000 lb per hr and one for 8500 lb—all designed for 160 psi working pressure—supply the necessary steam power to maintain required loads on all heating equipment, process equipment, water heaters, etc., throughout the entire project.

Each is fired by means of mechanical atomizing type oil burners with auxiliary equipment which includes pumps, storage tanks, heaters, gages, safety control, etc.

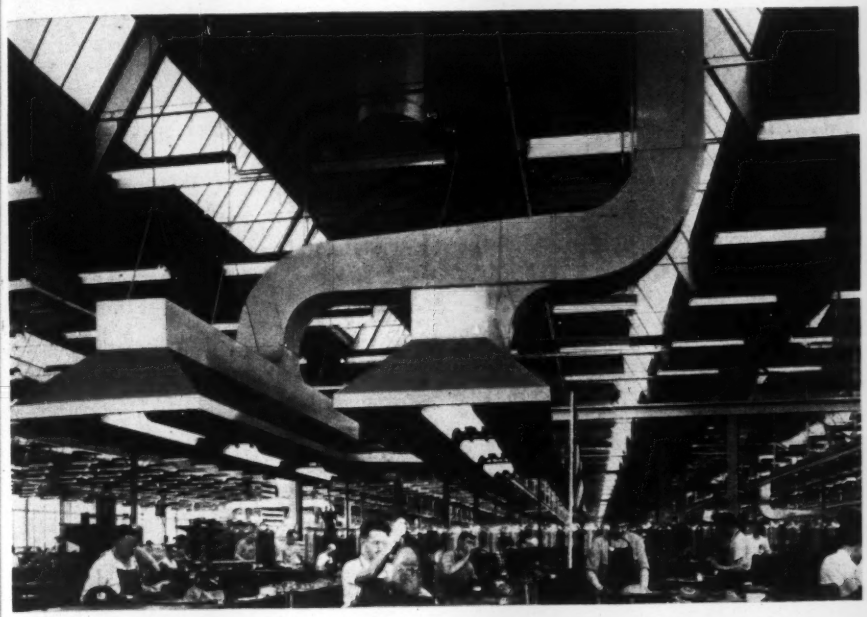
Forced and induced draft fans provide for proper combustion.

For supplying compressed air to the factory area, there are four 4000 psi and five 100 psi motor driven air compressors in the boiler house.

This project was designed by Albert Kahn Associated Architects and Engineers, Inc. R. C. Wieboldt Co. was the general contractor, and J. J. Corboy Co. was the heating and ventilating contractor.

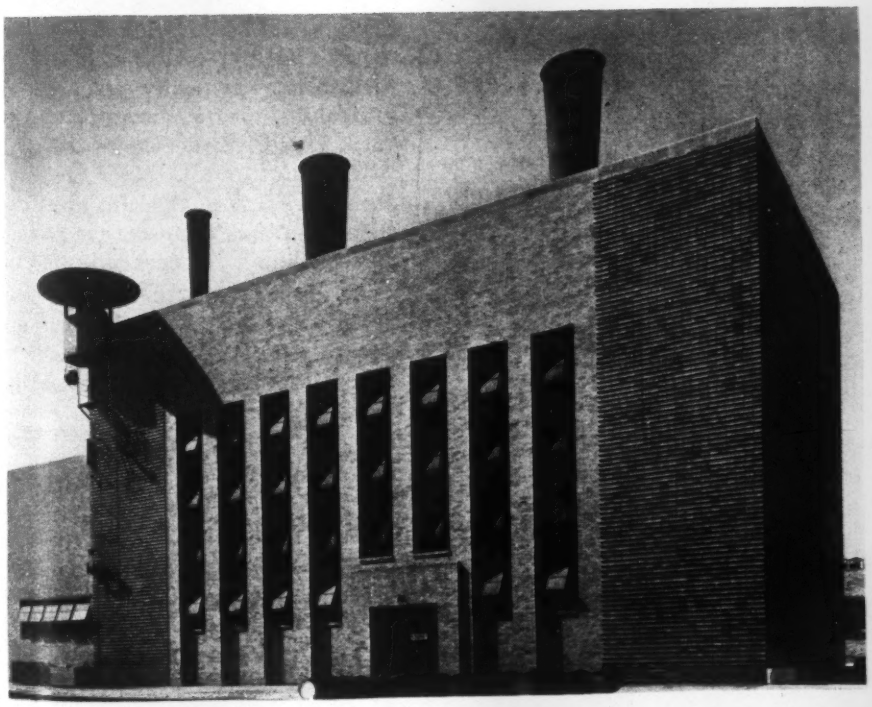
ABOVE

Traveling through the main manufacturing area, one notices the neatness with which the blow pipe and dust collecting work are installed



BELOW

Three multiple drum bent tube boilers, oil fired, in the boiler house, supply steam for all of the heating, process, and water heater equipment



STOKER MANUFACTURERS REVIEW A BUSY YEAR

In reviewing the progress made in the stoker industry in 1943, J. M. McClintock, president of the Stoker Manufacturers Association, said last month that the industry, under trying wartime conditions, "had written its record indelibly in the nation's industrial and home front achievements." When the conversion from oil to coal was stopped in the early fall of '43—which practically stopped the sale and installation of stokers on oil fired jobs — the stoker industry went to work, with the approval of the War Production Board and other government agencies, on a conservation campaign to save coal by converting hand fired commercial and industrial plants to stokers.

This program is still being aggressively pursued by the manufacturers and their sales organizations and the industry is preparing a 1944 campaign which will save many hundreds of thousands of tons of additional coal, as well as effect important savings in rail transportation and labor, according to Mr. McClintock.

SAM LEWIS' PAGE

Samuel R. Lewis, Consulting Engineer and Member of HPAC's Board of Consulting and Contributing Editors, Starts Argument on

Names for Things

It is my wish to start an argument concerning names for things, in the hope that it may not only be helpful to this profession but also amusing. Engineers invent improvements and new things but they are seemingly unable to invent logical names for them. Perhaps this is because most engineers of the present generation who write specifications were so crammed in college with mathematics that development of literary imagination was neglected.

In the misty past, a thing which condensed steam when exposed to a rapidly moving current of air was made of piping and could by some license be called a pipe coil. Such things are no longer made of coiled pipe, but even though they may be cast iron slabs or straight tubes pushed through thin sheet metal plates, they are frequently called "coils."

A valve is supposed to be something which opens or closes a passage to permit the flow of a liquid or gas. There is no great difficulty in understanding a gate valve or a check valve or a solenoid valve. Perhaps, under this definition, a device designed for installation on the outlet end of a steam radiator for passing condensate into a return pipe is a valve, but the limitation to the more definite function of "trap" seems more reasonable.

A radiator is that which radiates. Custom has limited use of this term to a metal vessel containing steam or hot water and not encased and not exposed to mechanically circulated air. Such devices may be obsolescent, since the tendency is to enclose the heat transmitters, to reduce greatly their weight and size, and to reduce their average temperature by attaching to them extended solid surfaces. In England the extended solid surfaces applied to heat transmitters and which reduce the average temperature are called "gills." Certainly this term is more descriptive to an unprejudiced reader than is the term "fins."

There is no definite name which permits a specification writer to describe an enclosed gilled heat transmitter intended to be placed in a room and to bring about circulation of air and a change in air temperature, the air to be moved without application of fan power.

One requires boldness to suggest that "gravity" is not an elegant term to describe in one word the circulation of air induced by effectively applied heat. This boldness has been acquired, and hereinafter it shall by myself be called "thermal" as differentiated from "mechanical."

A convector is supposed to be a heat transmitter which transmits heat by motion of its parts, and it seems that this term should be applied only to a heat transmitter that by location or enclosure cannot be a radiator. If the understanding can be developed that the term applies only to heat transmitters placed in air passages having mechanically induced movement, the situation might be improved. This seems to leave no fit name for a gilled heat transmitter placed in a room and limited to thermal air circulation.

A unit heater originally seems to have been a convector in a more or less portable box which also supported a direct connected, axial flow fan.

A heating unit may be anything that transmits heat.

What to call a thing that looks like a unit heater but that heats a refrigerant by forcing air against the convector in which a liquid or gas colder than the air, is moving? There is no elegance in calling this thing a cold diffuser. It is a convector. It may or may not be a unit evaporator. A definite name is desirable.

We seem to need a name for a part of a piping system such as a main pipe. One gets weary of reading that it is a "line."

A boiler originally meant a vessel in which water was evaporated into steam by contact with fire. The same physical device could be used to heat water but was prevented from boiling water when used in a hot water heating system. It was, however, still called a boiler. Then a metal tank full of water for lavatory purposes was connected by piping to a heat receiver and also was called a boiler.

Strangely enough if the same sort of tank is provided with an internal steam or hot water heat transmitter it is not called a boiler.

A coil means a spirally shaped pipe. Apparently a U tube internal steam heat transmitter inside a hot water tank is not a coil and should not be called a coil.

One cannot find that an aquastat means anything but something to do with water. There is logic in the growing custom of promoting it to mean a device capable of controlling the temperature of any liquid, as differentiated from a thermostat—a device capable of controlling the temperature of any gas. This gives license to the term "thermostatic trap," since the heat-sensitive device therein does respond to a gas temperature as well as to a liquid temperature.

A great step in advance was made when an Mb (1000 Btu) appeared. A great pleasure will be experienced at the funeral of the moribund square foot. Of course it is too much to hope that I shall live to see us adopt the metric system, but its coming is predicted.

Will not some erudite philanthropist suggest some reasonably descriptive names which will reduce confusion, ink, and paper wastage for some of the other items above suggested?

YOU ARE invited to comment on Mr. Lewis' remarks about Names for Things. Address The Editor, Heating, Piping & Air Conditioning, 6 N. Michigan Ave., Chicago 2, Ill. Suitable contributions will be published in these pages and paid for at customary rates. What are your views?

WPB...OPA...PAW...Etc.

New Government Orders, Revisions, Amendments

L-126 Allows Copper and Aluminum for Refrigeration, Air Conditioning

The WPB announced January 11 it had changed specifications to permit greatly increased use of copper and aluminum strip and tubing in the manufacture of commercial and industrial coil and tube assemblies for refrigeration condensers or coolers. The two amendments, which alter schedules III and IV of limitation order L-126, permit the following changes in the manufacture of coil or tube assemblies for refrigeration condensers or coolers:

1) Permit the use of nonferrous metals in the fabrication of coil or tube assemblies for coolers of the finned type only, for coil or tube assemblies to be used in farm milk coolers of the immersion type and for pipe and tubing in water and brine coolers of the shell and tube type.

2) Remove the restrictions on the thickness of fins used in the fabrication of coil or tube assemblies for air cooling.

3) Permit the use of nonferrous metals in the fabrication of replacement coil or tube assemblies when the assembly is to replace an existing assembly of like metals.

In addition to the relaxations permitted on the manufacturing processes, servicemen or repairmen will be permitted to use copper or copper base alloy pipe or tubing for refrigerant connections. The amended order still prohibits the use of copper or copper-base alloy pipe or tubing for service connections such as water and drain lines.

Purchase of Much Heating Equipment No Longer Restricted

Consumers who wish to purchase heating, plumbing, and cooking equipment, with certain exceptions, no longer need authorization from the WPB, it was announced January 17; formerly, an A-10 or better rating was required. Among the items of equipment which are free from this restriction are condensation pumps.

Purchase by consumers of rationed items, those under specific allocation, and those on a special restricted list is still controlled. Commercial cooking and dishwashing equipment, stokers with a capacity in excess of 60 lb per hr, domestic type oil burners, and extended surface heating equipment are specifically allocated. Furnaces, boilers, water heaters, range boilers, and cast iron tubular radiators comprise the restricted list.

The change was made effective by an amendment to order L-79; this revised order also provides that any consumer who wishes to purchase for replacement purposes an item on the restricted list A of the order need only certify to his dealer that it is needed to replace equipment worn out, damaged beyond repair, or destroyed, and that it will not be used to replace usable equipment or to make a substitution which would provide more extensive facilities. If, however, a consumer wishes to purchase for other than replacement purposes some item of equipment on the restricted list he must apply to his local WPB office for a preference rating before purchase can be made.

Although consumers may now purchase a majority of heating, plumbing, and cooking equipment without WPB authorization, sellers have been assigned a rating of AA-3 to enable them to purchase and maintain an inventory of such equipment for replacement purposes as well as for new installations. Previously sellers applied individually for ratings on PD-1X applications. The AA-3 rating is available for all sellers of heating, plumbing, and cooking equipment, and it may be used by repairmen to purchase capital equipment.

Although CMP regulation 9-A had previously assigned an AA-3 rating for use by repairmen in obtaining repair parts and materials, use of the rating to purchase capital equipment such as furnaces and boilers for replacement purposes was not permitted. Since experience has demonstrated that it is impracticable to distinguish between repair items and capital equipment in the plumbing and heating field, the revised order provides an AA-3 rating for use by repairmen in obtaining items of capital equipment.

Rationed items and certain items under specific allocation, list D of the order, cannot be obtained by an AA-3 rating. However, repair parts for such equipment can be purchased under that rating and sold to consumers without authorization or rationing certificates.

In addition to eliminating a great deal of paperwork, the revised order further simplifies operations by reducing the number of orders concerned with the sale and distribution of heating, plumbing and cooking equipment. Orders P-84 and P-84-A formerly assigning a rating for such equipment for replacement and repair purposes were revoked since order L-79 now provides for these items.

Production of heating, plumbing and cooking equipment, and the use of critical materials to produce it, are controlled by other orders and are not affected by the change in order L-79.

Freon-12 Restrictions Continued To August 31 by M-28 Order

Restrictions on the use of F-12 gas ("Freon") will be continued until August 31, the WPB announced January 20. Originally, the restrictions were scheduled to be lifted on March 31; however, delays in the construction and operation of a new plant, and an estimated shortage in the supply of anhydrous hydrofluoric acid, which is used in the production of "Freon," make the extension of restrictions necessary, WPB said. The businesses and services prohibited by conservation order M-28 from acquiring or using new "Freon" are amusement parks, animal hospitals, auditoriums, ballrooms, dancing studios, and dance halls, bank and loan associations, bars, cocktail lounges, and beer parlors, bowling alleys, concert halls, funeral parlors, golf clubs, country clubs, athletic clubs, and all other clubs and club houses, hotels and apartment houses, moving picture houses, night clubs, office buildings and offices (public or private), railway, streetcar, and bus stations and terminals, residential buildings and dwellings of all kinds, restaurants, cafeterias, and other places selling meats, food, or beverages, schools, service establishments (such as laundries, cleaners and dyers, tailor shops, barber shops, "beauty" parlors, automobile sales and service shops, and repair shops of all kinds), skating rinks, stores selling any kind of products, material or merchandise, at retail or wholesale (excluding manufacturing establishments), studios of all kinds, theaters.

MRO Preference Ratings Changed by CMP5 Regulation

Preference ratings available to various industries for maintenance, repair, and operating supplies (MRO) have been adjusted to reflect a revised pattern of relative urgency, the WPB said January 10. The ratings have been adjusted by means of changes in the lists of CMP regulation No. 5. Those industries which are included in list I are eligible to use an AA-1 preference rating, and those in list II an AA-2 preference rating to obtain MRO items.

Water Heaters for Replacement, Maintenance Need No Rating

Both new and used direct and indirect fired water heaters may now be sold to consumers for replacement and maintenance purposes without ratings, the WPB announced January 22. A purchaser need only certify to his dealer that such equipment is needed to replace equipment worn out, damaged beyond repair, or destroyed, and that it will not be used to replace usable equipment or to make a substitution that would provide more extensive facilities.

Provisions of order L-185, which limited sale of such equipment to orders rated A-10 or better, were revoked to bring that order into conformity with the provisions of order L-79, which was recently amended to simplify the sale and to eliminate unnecessary paperwork in connection with the sale of heating, plumbing and cooking equipment.

Order L-185 was primarily concerned with production of water heaters. Order L-79 now controls the sale of heating, plumbing and cooking equipment. Order P-84, which assigned a rating of AA-5 to purchase of water heaters by consumers for replacement and maintenance purposes, was revoked January 15 when L-79 was made the controlling order over sale and transfer of such equipment. Sale of these heaters for other than replacement or maintenance purposes is still subject to WPB approval; industrial and commercial users should apply on WPB form 541. Purchase of water heaters by sellers is now controlled by L-79, which assigns a rating of AA-3 to enable them to purchase and maintain an inventory of such equipment for new installations as well as for replacement purposes.

L-252 Amendments Permit Brass or Bronze for Valve Nuts

Manufacturers were granted, January 6, permission by the WPB to use either brass or bronze in making nuts for several categories of valves. This permission was granted in specifications for nuts for packing gland flange bolts or studs in manufacturing iron gate valves and iron globe and angle valves. Previously, only carbon steel had been permitted for these purposes, the shipbuilding division of WPB said. The use of brass or bronze also is allowed in the manufacture of nuts for attaching the swing check disc to a hinge or arm of an iron check valve. Previously, only carbon steel or malleable iron was permitted for this purpose. The changes are included in amendments to limitation order L-252.

Priorities Regulation No. 13 On Idle and Excess Materials Revised

Priorities regulation No. 13, governing special sales of idle and excess materials, has been revised in order that all regulations issued prior to December 22 shall have no effect on redistribution of such materials, the WPB announced December 24. The only exceptions to this general rule are directive No. 16, governing aircraft inventory transfers, and order P-98-c, governing special sales in the petroleum industry. To find the rules governing a special sale of idle or excess materials, there is no need to refer to any order or regulation other than priorities regulation No. 13, outside of the two stated exceptions. However, orders issued after December 22, which may specially indicate that priorities regulation No. 13 has no effect, shall govern special sales of items which they may cover.

L-187 Provides for 1944 Cast Iron Boiler Production

Production of cast iron boilers during 1944 equal to 100 per cent of the number produced in 1940 was provided for January 1 by the WPB in an amendment to order L-187. It places the quota allowance for 1944 production on a quarterly basis. Each manufacturer may produce each quarter 25 per cent of the low pressure cast iron boilers he manufactured in the whole year of 1940. However, the provision is made that any producer may exceed this quota if he obtains permission from the WPB. Quota assignments include production for all purposes, including the armed services, hospitals and war housing. Quota limitations do not apply to the manufacture of repair parts for boilers.

Steam Heating Boiler Scheduling To WPB Plumbing and Heating Division

Scheduling jurisdiction over steam boilers of the type generally used as heating equipment has been transferred from the power division of the WPB to the plumbing and heating division, it was announced January 22. The action was taken to permit deliveries of boilers of this type to be scheduled by the plumbing and heating division in line with requirements for such items. It was accomplished by eliminating the types of boilers which had been under jurisdiction of the plumbing and heating division from Table 1 of order M-293, the general scheduling order, and by adding a new table 14, covering products under the jurisdiction of the plumbing and heating division.

Control Valves for Hydrogen Fluoride Exempted from L-134

Control valves and regulators for hydrogen fluoride service were exempted from the restrictions on inner valve and seat ring construction contained in limitation order L-134 through an amendment to the order issued December 24 by the WPB. These valves are used primarily in gasoline production, and the exemption is essential from an engineering standpoint, WPB said.

Industrial Users Must Reduce Bituminous Coal Orders

Amendments to regulations which will require certain industrial consumers to make further reductions in their orders for bituminous coal so that a larger share of the current mine output will be made available for diversion to users distressed for lack of fuel, were announced January 19 by Solid Fuels Administrator Harold L. Ickes. They apply to industrial plants which have stockpiles sufficiently large for them to draw on for part of their current coal consumption needs, and require industrial plants and public utilities supplied from mines in the eastern half of the nation which have more than 25 and 40 days' stocks, respectively, on hand to reduce their orders for coal still further, and use more coal from their storage piles. Because of the transportation problem, plants in Canada and those in the United States obtaining coal via Atlantic coiler or New York harbor, are allowed to hold an additional 15 days' supply without having to reduce orders. The specific amount by which the industrial users affected are required to reduce their orders, beginning with February shipments, depends upon the size of their storage piles.

Uniform Methods of Establishing Maximum Prices for Valves

Manufacturers of approximately 1000 different kinds of manually operated valves have been provided a uniform method of establishing maximum prices for sales to producers of various types of appliances, the OPA announced January 13. Because of limitation and conservation orders relating to materials used in their manufacture, about 90 per cent of these types of valves have not been produced since 1941, and the remaining 10 per cent not since July 1942. Recent WPB permission to resume production of appliances using these valves has created a pricing problem for the gas appliance valve industry. Most types of these valves do not have maximum prices established since they were not offered for sale during March 1942. The small percentage of types that were sold during that period have maximum prices that are not appropriate under present conditions.

(Amendment No. 26 to order A-1 under section 1499.159(b) of maximum price regulation No. 188—manufacturers' maximum prices for specified building material and consumers' goods other than apparel, effective January 13, 1944.)

Sale of Evaporative Air Coolers Under L-38 Order

Utility Fan Corp. pointed out last month that limitation order L-38, as amended December 6, includes provisions for production and sale of evaporative air coolers, as well as refrigeration and air conditioning equipment. Evaporative coolers may be sold on AA-5 or better priority without specific approval from WPB, to the Army, Navy, Maritime Commission, War Shipping Administration, National Housing Administration, or any person requiring a cooler for any essential use shown on list C of the order. Evaporative air coolers may be stocked for inventory or resale when WPB approval has been obtained on form WPB-547 (PD-1X).

Ban On Natural Gas Deliveries Extended by U-7 Directive

To husband supplies of natural gas in the Appalachian area, pending completion of a new pipe line from Texas to West Virginia, the WPB's Office of War Utilities has extended its ban on deliveries to include industrial and commercial users having standby facilities capable of burning any type of fuel other than liquid petroleum gas. Previously, only those consumers with standby facilities for burning bunker oil were limited in their receipts of natural gas to amounts needed to supplement the power generated by their standby equipment. Amendment of directive 1 to utilities order U-7 imposes the new restrictions during the period from January 12 to March 31.

MPR 465 On Used Pressure Vessels Amended

Sellers of installed used vessels, such as underground gasoline and fuel oil storage tanks, may be compensated for a portion of the original installation cost when that cost was in excess of $100, the OPA announced January 6. Amendment 1 to MPR 465 permits the addition of installation costs, when in excess of $100, to the maximum price established for used vessels, which have been installed below the ground and will be used by the purchaser in the same location as when purchased. The amount of such installation cost will be depreciated at the rate of 5 per cent per year for the time elapsed since installation was made.

Motor and Oil Burner Repairmen Are Critical Occupations, Says WMC

The jobs of all-around repairman of electric motor equipment and all-around repairman and installation man of oil burner equipment have been added to the list of critical occupations, the War Manpower Commission announced January 6. Workers possessing skills in critical occupations are subject to particular consideration in connection with Selective Service classification and in connection with selective placement activities of local United States Employment Service offices.

Sprinkler Head Shipments Put On Quota Basis

Shipments of sprinkler heads, which are the outlets for the water in fire sprinkler systems, have been placed on a quota basis, the WPB announced January 13. For the year beginning November 1, 1943, and for subsequent years, each manufacturer is limited to shipping 78 per cent of the number of sprinkler heads he shipped during 1941. In any six months' period, his shipments must not exceed 70 per cent of his quota for the entire year. Inventory is also restricted. These provisions are set forth in order L-39-a.

Producers May Increase Prices On Certain Insulation Board Sales

Producing manufacturers of fiber insulation board products may increase present ceiling prices in sales to nonproducing manufacturers, providing specified conditions have been met, the OPA announced January 12. Any increase in price must be absorbed by the buying manufacturer and may not be reflected, directly or indirectly, in his resale price. Fiber insulation board products are defined as insulation board and roof insulation subject to the same specifications and standards set forth in a classification of the products by the Department of Commerce effective August 25, 1943.

MRO Procedures by Institutions Modified by Revised CMP 5A Regulation

Rules governing use of MRO procedures by institutions and government agencies have been modified and conformed to recent WPB policy changes in a revision of CMP regulation No. 5A, the War Production Board announced recently.

The amended regulation eliminates institutions or government agencies engaged in operating sanitary sewage systems or storm sewage systems combined with sanitary sewage systems from using the procedures which it outlines.

Institutions or government agencies maintaining central storage operations may, under the amended regulation, apply to WPB for a blanket rating to cover all purchases made for the store, rather than attempt any apportionment of supplies among its various operations.

The regulation also points out that form WPB-837 (formerly PD-408) was discontinued as of September 30, 1943, but that orders placed before that date to which ratings or MRO symbols were assigned on such form may be filled.

It also permits institutions and agencies eligible to use its procedures to obtain up to 500 lb of aluminum per quarter rather than the 100 lb formerly allowed.

Electric and Gas Utilities Authorized to Build Short Line Extensions

Electric and gas utilities have been authorized to build short line extensions to serve a substantial number of consumers who have previously been unable to obtain service, the Office of War Utilities announced December 10 in releasing a series of amendments to supplementary orders.

New electric and gas service lines heretofore have not been available to persons living outside critical housing areas, except when they were built as a part of a war housing project. An amendment to supplementary utilities order U-1-f removes the restriction that limited utility construction of this type except in critical housing areas.

Other minor changes have been made in amendments to U-1-a, U-1-c, and U-1-d; U-1-b has been revoked and is superseded by U-1-d and U-1-f, which retain its substance.

Restrictions on Boiler Production for Stock

Restrictions on production of boilers for stock have been made applicable to the types subject to the scheduling jurisdiction of the plumbing and heating division, the WPB announced January 31. The action prohibits the manufacture for stock of high and low pressure steel boilers of the types listed in table 14 of general scheduling order M-293 without the specific authorization of WPB.

Praises Production Achievements of Valves and Fittings Industries

Production achievements of the valves and fittings industries were praised by Captain J. O. Gawne, director of the WPB shipbuilding division, at a meeting called last month to review production problems. The valve industry has expanded its steel valve output to approximately 7½ times its pre-war level, Captain Gawne said. Last year the industry produced valves of steel and other metals to an estimated total of 277,525 tons, or more than 99 per cent of stated 1943 requirements. Fittings production also has been stepped up, and is currently at a level of 2½ times that of 1938. In the year just completed, the production of fittings was 29 per cent higher than stated requirements of government claimant agencies.

Recent Amendments to OPA Fuel Oil Rationing Order

An index to amendments Nos. 1 to 50 to the fuel oil rationing order (RO 11) appeared on pp. 171-172 of the April 1943 HPAC. Amendments 51-60 were covered on p. 233, May; amendments 61-65 on p. 52, front section, June; amendments 66-71 on pp. 411-412, August; amendments 72-73 on p. 466, September; amendments 74-78 on p. 537, October; amendments 79-82 on pp. 174-175, back section, November; amendments 83-88 on p. 661, December; and amendments 89-92 on p. 34, January 1944.

Amendment 93, effective February 5—To enable a consumer to buy fuel oil during the period an OPA district office is investigating the loss or theft of his ration coupon sheet, this amendment provides for the issuance of an interim coupon sheet by the consumer's local war price and rationing board. Under former regulations, when a local board asked the district office to investigate the loss or theft of a coupon sheet, the consumer had to wait as long as 30 days before action on the application.

High Pressure Vessel and Piping Welding Is Critical Occupation

The job of electric arc welder and high pressure vessel and piping welder has been added to the list of critical occupations, the War Manpower Commission announced January 17.

WMC pointed out that the only persons included under this title are those who use an electric welding apparatus in welding metal parts in the fabricating, erecting, or repairing of pressure vessels of carbon or alloy steel fabricated in conformance with codes of the American Society of Mechanical Engineers and the American Petroleum Institute. It does not include welders working on any pressure vessels that do not bear the official stamps of approval of the ASME.

Copper Order M-9 Simplifies Regulation

To streamline the regulations governing copper raw materials, a new copper order was issued by the WPB last month. The new order (M-9) supersedes two orders that were revoked (M-9-a, copper base and copper base alloys, and M-9-b, copper scrap and copper base alloy scrap). In addition, WPB issued direction 1 to the new copper order for the purpose of maintaining a steady flow of needed grades of copper scrap and preventing the accumulation of needed copper scrap in the hands of scrap dealers.

The order gives in tabular form the restrictions on acceptance of delivery of copper raw materials. This makes it possible for a person in any category, such as a foundry or a brass mill, to see at a glance the copper raw materials he may receive without having to apply to WPB, and the WPB form on which to apply for specific authorization to receive other copper raw materials.

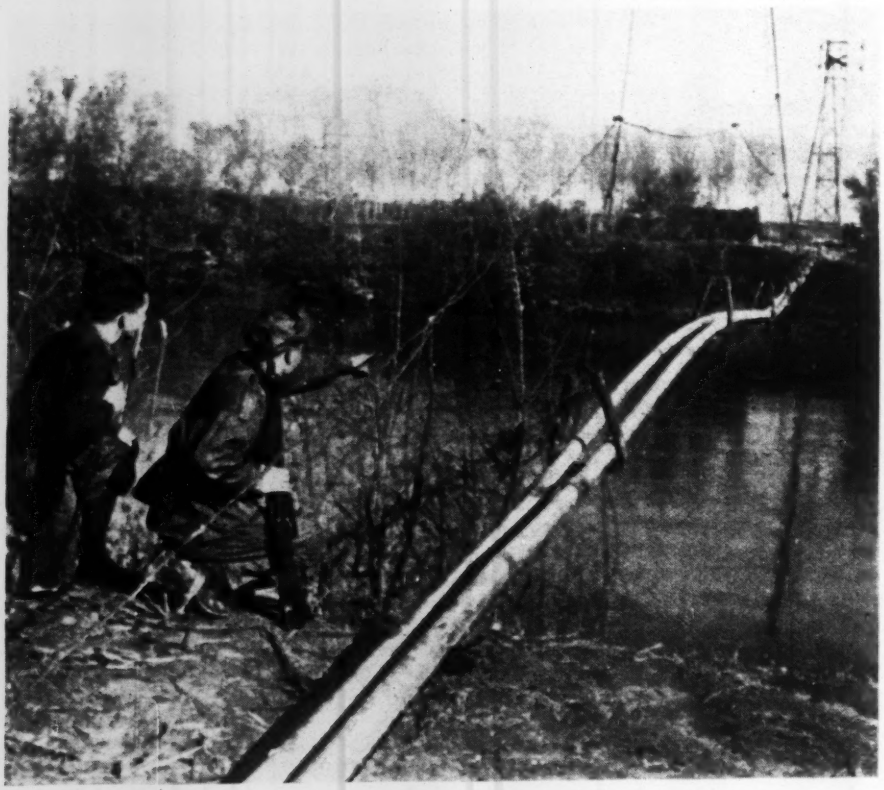
Other Government Actions Announced Last Month

BRASS TUBING RESTRICTED. WPB announced that it has prohibited manufacture of new brass or copper tubing, pipe, or fittings for installation in gas supply and gas distribution systems. (Conservation order M-9-c, as amended, effective January 22.)

LIGHT WEIGHT TUBING ALLOWED. WPB announced that it has permitted resumption of manufacture of light weight tubing, used largely by gas well operators in eastern area. (Limitation order L-211, schedule 9, as amended.)

CERTAIN OIL MATERIALS RELEASED. Acting to encourage further oil industry's efforts toward increasing nation's petroleum supply, PAW announced relaxation, as much as present situation will permit, of certain restrictions on use of critical materials in crude oil production and natural gas and natural gasoline operations. Action was taken in an amendment of a formal order (No. 11), which became effective January 1.

MAY REPLACE CERTAIN OIL BURNERS. Domestic type oil burners over 10 years old or those beyond repair may be replaced restriction-free from dealers' stocks, WPB announced. In other replacement cases, however, prospective purchaser must obtain approval from district WPB office on form WPB-1319. Revised order (an amendment to order L-74, oil burners) also frees dealers' stocks of oil burners for new installations provided that Petroleum Administration for War has approved in writing delivery of fuel oil for such burner on premises in question.



PIPE LINE SUPPLIES OIL TO FRONT LINES

An oil pipe line, constructed and put into operation in just one week, winds its way from an Italian port to a point just behind the front lines. Here the line crosses a river, with previously built high tension towers used for support. In river crossings, the line is welded instead of coupled "to add strength and flexibility" (Acme)

KEEP 'EM PUMPING!

Fred D. Mosher Outlines Some Well-Known, Sometimes Forgotten Facts on Maintenance

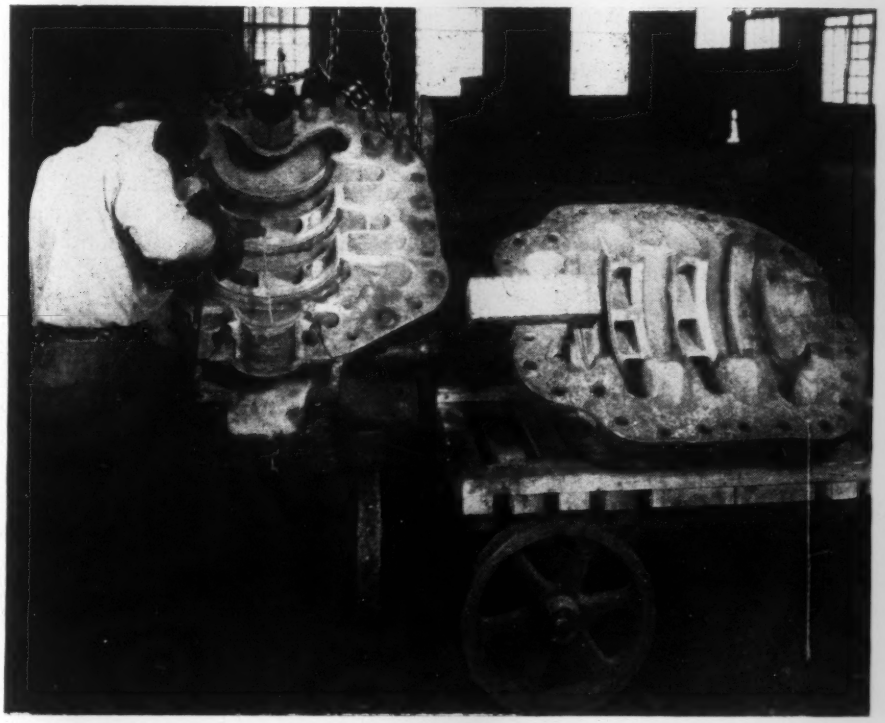
PUMPS OF all kinds are on the critical list, and for the duration efforts must be intensified to keep existing machines in good operating condition. Pumps, for the most part, operate with a minimum of attention, and when designed properly for the job to be done they usually give a good account of themselves, but with the emphasis being put on maintenance the whole problem of pump care might well be re-examined with profitable results.

Pump Inspections

The making of daily pump inspections is time well spent. The smooth operation of a pump requires that it be kept well oiled, and the daily inspection should see that lubricators are filled and that grease cups are providing ample lubrication. Operators or maintenance personnel who make the daily inspections should be on the alert for noisy operation, leakage, pulsating pressures, heating, and starting difficulties. Pounding valves should be reason for investigation, as should loss of head or evidences of air binding.

A monthly pump inspection should determine the condition of packing glands and stuffing boxes; the condition of seals should be noted. Pumps not equipped with pressure gages should have pressures checked by a test gage.

The yearly inspection should provide the maintenance department with a full story on the condition of each pump. Important pumps should be opened up annually for internal inspection. Regardless of condition, all packings should be renewed each year, except where service of a severe nature dictates more frequent renewal. Liners of cylinders should be examined for corrosion, since evidences that the liquid being handled is corrosive are often found in pumps and their connections. Rods and shafts ought to be checked for wear at the annual overhaul. Checks made at monthly inspections should be repeated at the annual outage. Where pumps are used seasonally for heating or air conditioning work, it is obvious that the idle period is the proper time to make the annual inspection.



Casing of centrifugal pump being repaired by welding. Important pumps should be dismantled at regular intervals to note effects of wear and tear

Common Pump Troubles

Most pump troubles are of a minor nature, and usually become serious only after a prolonged period. Once a pump has been selected for a given service, and has demonstrated in operation that it is capable of doing a good job, the difficulties which develop are most likely to be easy to correct. Assuming that a pump has been wisely selected and properly installed it must deliver the quantity of liquid for which it was designed; it must do its work efficiently; the power used must be reasonable for the work performed; the upkeep of the pump should be accomplished with a reasonable amount of maintenance; and outages should not be other than those scheduled for inspection, cleaning, packing, replacements, and adjustments.

Failure to deliver the amount required by a pump is a progressive condition which gets worse with time. Lift pumps frequently develop this trouble when leaks occur in the suction piping and joints; as breathing of the joints enlarges the air leak, the pump delivery is reduced. A gradual wearing or corroding of valves and seats will cause a pump to operate with lowered output. The scoring and normal wear of pump cylinders have adverse effects on the quantity of liquid delivered. Inside packed plunger pumps and piston pumps may lose capacity rapidly when packings become worn. The majority of pump troubles are confined to the suction side. Failure to maintain capacity on the part of a

centrifugal pump will result due to leaking past the seal rings and impeller hub because of increased clearance between the impeller and volute. Broken impellers, partially clogged vanes, and excessive leakage are also reasons for reduction of delivery.

Violations of ordinary operating rules may give trouble with pumps when units are put in service, but most difficulties result from poor maintenance, inadequate care, and the consequences of unchecked wear and tear.

Organized Maintenance

Maintenance work of any kind to be effective must be done on an organized basis. Pump maintenance is closely related to much other work done in refrigerating, air conditioning, heating, and power plants, and it should be a simple matter to delegate a member of the organization to handle all pump work. The number of units should be cataloged, and data, records, repair facilities, spare parts, and servicing materials should be available to those responsible for pump upkeep. To facilitate ordering parts and making replacements, nameplate data on each pump should be filed, and an inspection and repair card should always be kept on file, and discarded only when replaced by another.

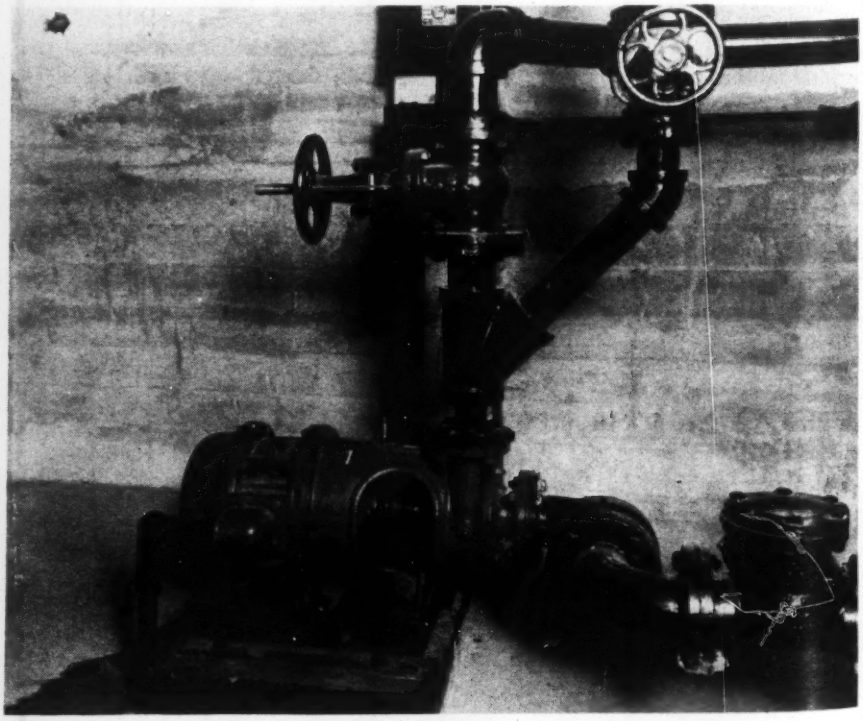
In addition to pertinent information as to size, capacity, speed, and instructions, the type of packing specified, the kind of lubricant required, and any changes made from the original should be on record. In answer to the protest that maintenance men are not bookkeepers, it should be stated that good maintenance requires that essential data on important equipment should always be available to those concerned with conservation.

Packings

All packings have a definite economic life and the fact that trouble does not develop within a year does not mean that a set of packings should be continued in service beyond that time. Chemical action, drying out, and disintegration of the materials make most pump packings go bad rapidly once the wearing out process begins. Dried packings lose their ability to seal rods and shafts, and repeated tightening of glands may score rods or actually distort them; to continue them in service when this condition exists is to invite troubles which may require costly outages and repairs.

The first requirement for a good packing is that it be suitable for the service in which it is to be used. It should be adequate for the temperature and pressure of the service, and where the liquid handled is corrosive, the materials must be of special quality to resist the chemical action. There are very few makeshift packings which may be used with success. Packings must be of the exact size required. Packing will not correct for pump defects such as scored rods, bad alignment, poorly fitted glands, or worn stuffing boxes. A packing chart is a useful tool to the maintenance man, and will aid in maintaining inventory and selecting the right packing for the right job.

When a pump is to be packed it should be prepared by removing all the old packing from the stuffing box. It is bad practice to add new rings to a number of old ones in a stuffing box. As the packing is removed it should be examined carefully for the story it may tell about the condition of the pump. A large industrial concern has made a thorough study of packings, their economic lives, and their effect on pump maintenance. Hundreds of used packing samples were examined and an accurate record kept on pumps and packings used. It was found, for example, that low bearings were indicated by the kind of wear suffered by the packing rings, and low bearings were found when the packing cross-section was reduced in the region directly beneath the rod or plunger. A misaligned rod or plunger reduced the packing cross-section directly over or on either side of the rod. When packing rings were actually missing from the stuffing box they were found to be forced into the pump by too much tightening of the gland. Poor fit is indicated by outside wear showing that the packing rings were loose and moving with the rod, which results when undersize packings are used. Any distortion of the old packing rings should be evidence that the previous packing job was done incorrectly, and all the evidence should tell a story of what is happening when the pump is in operation. Lack of lubrication would cause the packing to get a hard inner surface and scoring of the rod would support this. The new packing should



Flanges in lines connected to pumps must be kept tight. This type of installation should get regular gasket maintenance attention for best results

never be installed until the old rings are examined for the story they tell; this is one of the important ways to uncover and diagnose trouble.

Installing Packing

When all old packing is removed from the stuffing box to make way for the new rings, the rod, gland, and stuffing box should be thoroughly cleaned. Clean, new packing should be used. In cutting the new rings care should be taken to get good fit, and to see that there are no ragged ends. By taping the packing on either side of the place to be cut, a good, clean joint is obtained. An improvised mandrel the size of the pump shaft will aid in getting the rings cut to the exact size. Packings must seal without producing friction and packings should be thoroughly impregnated with lubricant. But packing must never be expected to carry weight since its function is to provide sealing only. Whether packing rings butt to a perfect fit or provide a slight clearance is a matter of choice, but in no case should rings be too long. The rings should be installed in the stuffing box so that joints are staggered clockwise at 90 deg. When lanterns are used care must be taken to prevent blocking of the openings when new rings are installed.

Packing rings should be pressed home firmly until the stuffing box is filled. After the required number of rings have been inserted the gland nuts should be tightened to seat the packing. The gland should be taken up evenly by passing from a bolt to the one diametrically opposite. A wrench may be used to tighten the gland initially. The gland, after being tightened, is backed off and taken up to finger tightness; the pump is returned to service with the gland at this tightness, and it is then taken up more only to provide the minimum leakage required for lubrication. Bolts with stripped threads should be reconditioned before the packing is done. Unused packings should be correctly labeled, and kept in clean containers which are tagged with proper identification as to size, quantity, and service. Packings should always be stored in a dry, cool place.

Gaskets

Gasketed joints should have their gaskets renewed each year, or as near to annually as operating conditions will permit. Before installing new gaskets the flange faces should be examined for scoring and cuts, and when found, corrections should be made before the new gasket is installed. Dope ought to be used sparingly and only on one side of the gasket, and in no case should grease or oil compounds be used as dope on rubber or rubber composition gaskets.

Idle Pumps

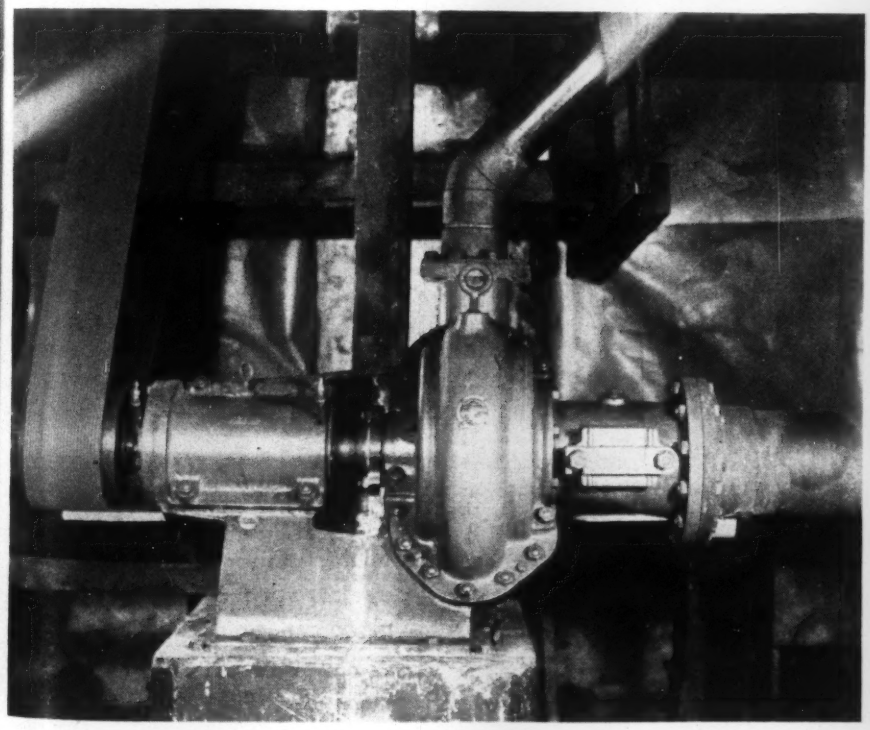
When it becomes necessary to lay up a pump for an extended period it should be overhauled and inspected in the regular way. All internal parts should be cleaned. If there is danger of freezing a water pump it must be drained or provided with heat during the idle period. If the pump is kept filled it should be operated at least once a week and the packing glands should be backed off between operations; if power is not available the pump should be turned over by hand. Idleness will most always render the packings useless and new packings should be installed in a pump, which has been idle for a long period, before it is returned to service.

[Photos courtesy Ingersoll-Rand, Lincoln Electric Co., and Worthington Pump & Machinery Corp.]

CED WORKING WITH 48,000 INDUSTRIAL FIRMS

Approximately 24,500 businessmen who are members of the Committee for Economic Development in 1230 communities in every state of the union are now working toward the goal of greatly expanded peacetime production and employment after the war, in close cooperation with businesses representing nearly three-quarters of the industrial capacity of the nation. This announcement was made February 3 by Paul G. Hoffman, president of the Studebaker Corp. and chairman of the CED board of trustees.

CED committees are working actively with approximately 48,000 industrial firms and corporations whose total output in 1939 represented $41.5 billion, about 73 per cent of America's total factory output, and nearly 6,000,000 jobs or 60 per cent of its factory employment.



Pump bearings should be inspected regularly for wear and alignment

THE MAIN STEAM HEADER

Heart of Your Piping System

G. W. Hauck, manager of engineering sales, Crane Co., discusses here—in practical, easy-to-understand style—the design, location, and fabrication of the main steam header in industrial plants requiring steam for processing or other purposes. Because, in the final analysis of costs, you pay for a good piping system whether you have it or not, careful consideration of the points suggested by Mr. Hauck when it comes to design of the "heart of the piping system"—the main steam header—is important.

MANY INDUSTRIAL plants are dependent upon an adequate supply of steam for processing or other purposes. The boiler plant is one of the important links in the chain of equipment and utilities needed to convert raw materials into finished products. This article suggests that the small or medium sized boiler plant, operating at relatively low or medium pressures, deserves the same elements of careful design as the larger central stations in the high pressure field.

The successful and economical operation of the boiler plant, with its contribution of steam for the manufacturing process, depends to a large degree upon a good piping system. Too often, the piping is relegated to a subordinate place in planning or design and is treated as an afterthought. As with many other things, you ultimately pay in the final analysis of costs for a good piping system *whether you have it or not.*

Even in a variety of industrial establishments, we find the boiler plants to be typical. Steam is generated in the boilers and then transmitted through the piping system to all sorts of steam-consuming apparatus—cooking kettles, pasteurizers, heat exchangers, hot water storage heaters, pumps, dryers, heating systems, and a host of others. The piping system is analogous to other forms of transportation systems which require a central control or switching station for efficient operation. We, therefore, focus attention on the main steam header because it is the heart of the piping system and should function as the central control station. What are some of the elements of good header design?

Location of the Header

In hundreds of industrial plants, it is common to find the main steam header running across the tops of boilers. This requires the operators to climb ladders, sometimes dodge breeching, or cope with other handicaps to operate valves at the header. In occasional emergencies there is a decided disadvantage in such a location for the "control station." Putting the header above the boilers or in any elevated location is largely a matter of habit established by long precedent. Actually, it cannot be justified whenever it is not necessary for some exceptional structural reason.

The ideal location is at a point near the floor where it will be readily accessible. The maximum height, preferably, should be one which puts all of the header valves within reach for comfortable operation from the floor. If the header is installed adjacent to a wall, and this generally is practical, space is conserved and the installation of supports is facilitated.

Header Branches

If a header is to be a good "control station," it should be carefully designed to obtain enough branch connections to provide flexibility in the operation of the piping lines. First, of course, the header should contain inlet branch connections for the steam leads from the boilers. The outlet branch connections should be sufficient in number to provide individual lines to the various steam-consuming units. Sectionalizing through a system of multiple branch steam lines permits the ready isolation of any one line without interfering with the continuing operation of the steam supply to other units.

Contrastingly, if a large branch steam line is run from the header to supply steam to units progressively at points along the length of this one line and reducing in size as it is extended, the plant may develop an awkward situation. Literally, "all of the eggs are in one basket." If the line needs to be shut down for any reason, such as the failure of one piece of apparatus somewhere along its length, the entire line must go out of service and other units will be shut down unnecessarily.

Instead of one large supply line, a number of smaller individual lines branching out from the header and separately valved at the header connections will provide a much greater flexibility in operation. For instance, there should be an individual branch connection at the header to supply steam to pumps and any other auxiliaries in the boiler room, thus making it self-contained and able to operate independently of the steam lines for process service. Usually a separate branch for supplying steam to the hot water storage heater is advantageous, as water can be heated at a time when the process lines are not in service. The number of branch connections needed to provide the steam supply for processing apparatus depends upon local conditions.

Each branch connection should be provided with a valve at the header if the maximum operating flexibility is to be achieved at this "control center."

Size of Header

A main steam header as described previously should be as compact as possible. Designing the

header for minimum length permits increasing its diameter slightly in size to obtain a moderate receiver capacity. For instance, if a long header would normally be 8 in. in size, a short and compact header for the same plant could be increased to 10 in. without any sacrifice in economy and it would reflect an improvement in design.

As a general broad rule, header connections 1½ in. or 2 in. and smaller can be screwed; 2 in. or 2½ in. and larger should be flanged, in this typical industrial boiler plant operating at moderate or relatively low pressures.

Spare Openings

If future expansions are definitely known, such as another boiler or another pump, etc., the required connections often can be provided in the header design. Even if future changes or additions are not known or contemplated initially, one or two spare openings should be provided and blanked off. Then a change requiring a new connection from the header will not involve a lengthy shutdown, the removal and replacement of insulation, or an improvisation which compromises good design. A spare opening is an investment which often pays a good dividend.

Drainage

If the header is near the floor as suggested, it is ideally situated for the drainage of condensate, being at the low point of the system. The header should be provided with one or two drip pockets, the number depending upon the length of the header. The drip pockets should be equipped with steam traps for the automatic drainage of the condensate. Steam flow conditions often will produce enough difference in pressure drop in even a short distance to make it advisable to install individual steam traps on each drip pocket.

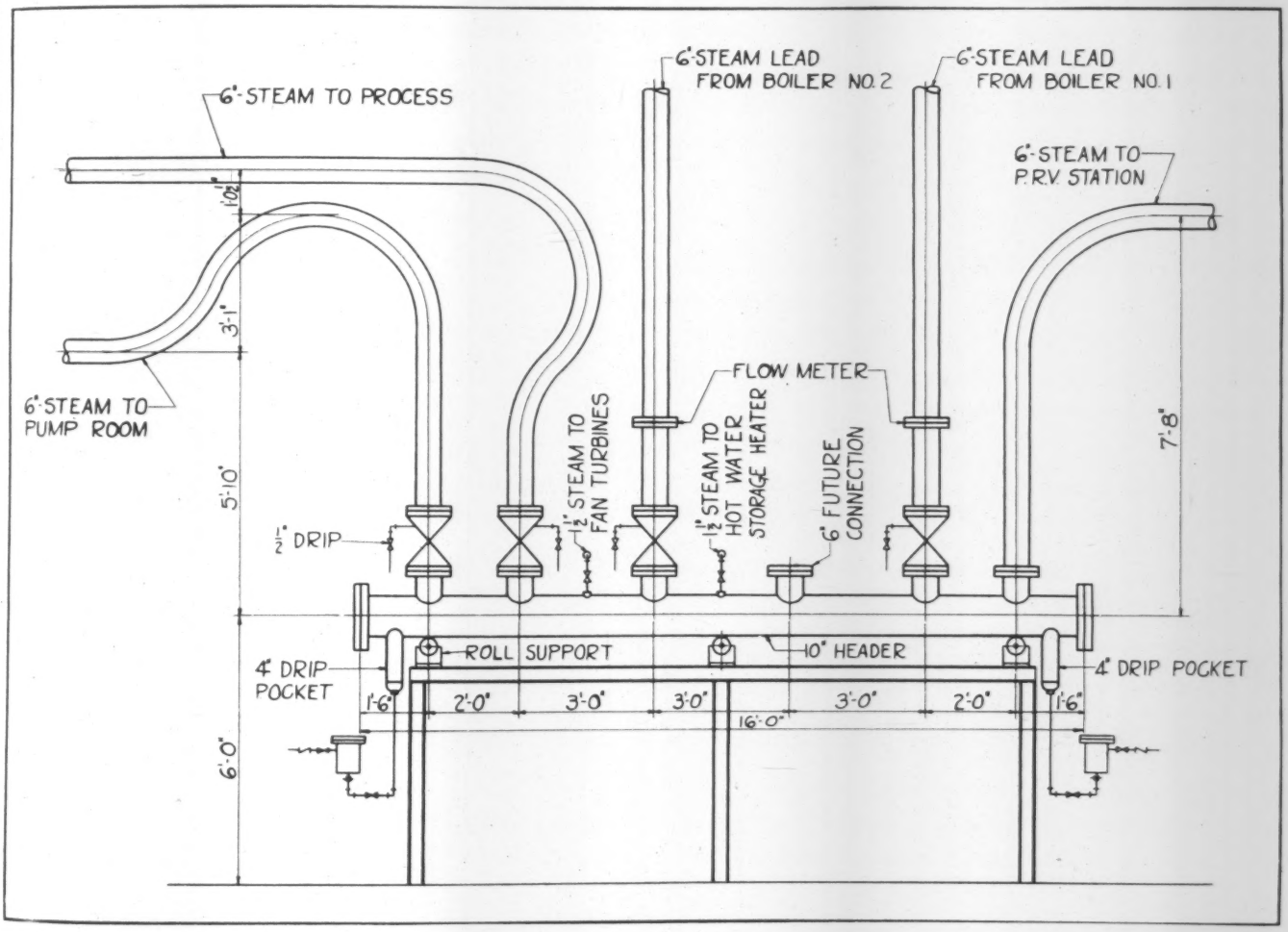
The photograph and sketch show the main steam header and its branch connections in the boiler room of an industrial plant. Steam is generated at 160 psi pressure, saturated. The design typifies the desirable features which have been enumerated.

An Illustrated Example

The boiler outlets (not shown) are approximately 26 ft above the floor line, while the header is only 6 ft above the floor. All valves are readily accessible for easy operation from the floor, yet there is ample headroom. Incidentally, the 6 in. valve in the steam line to the pressure reducing valve station is not shown in the sketch but is discernible in the photograph. It was placed at the reducing valve station to achieve a compact grouping of the main and bypass valves at one point.

All branch connections are individually valved. Over weekends, steam to process and the pump room can be shut off while steam flow is maintained to the heating

This header embodies features discussed in text



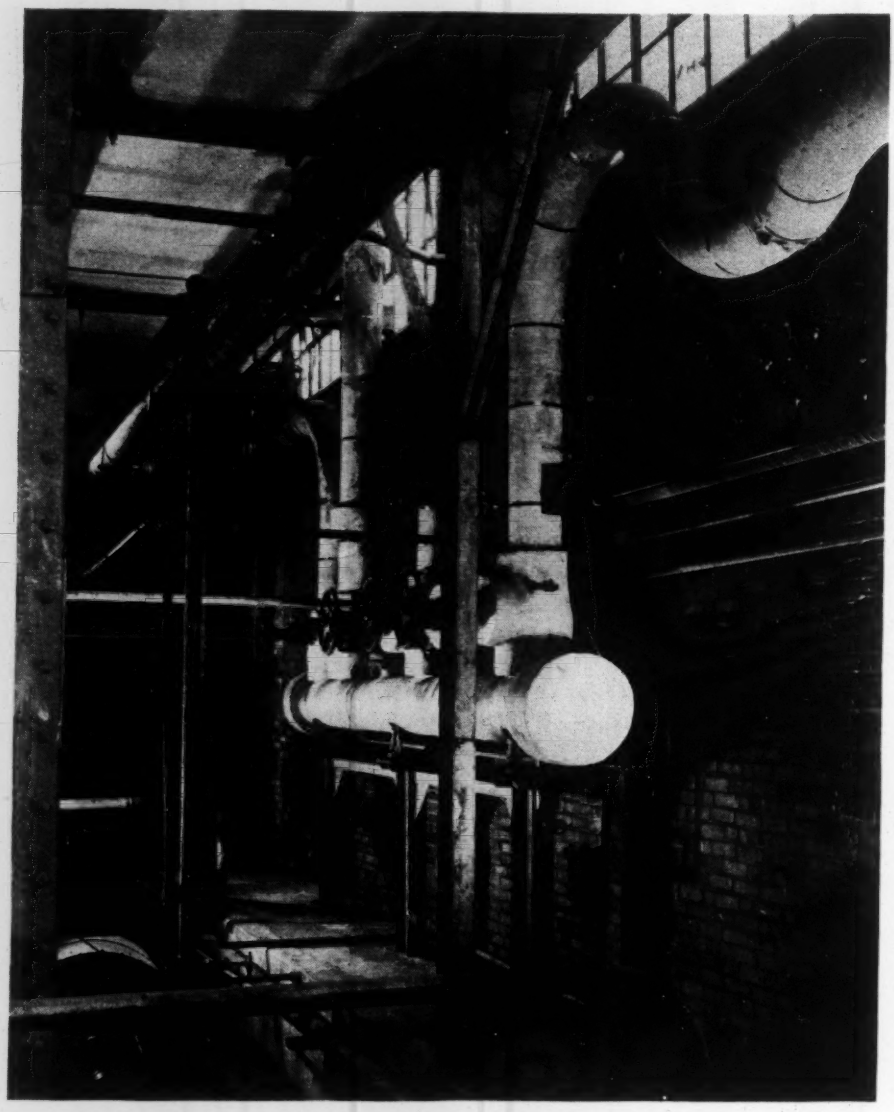


Photo of header sketched on preceding page

system and the boiler room auxiliaries.

The boilers were installed 22 ft, 0 in. from center line to center line. The boiler leads were designed to permit a relatively short header only 16 ft, 0 in. long. A 6 in. connection equipped with a blind flange provides for a future steam line. The two 4 in. drip pockets with individual steam traps provide excellent drainage of condensate as the header is at the low point of the piping system.

Welded construction is probably the best method for producing a header with all of the features described and illustrated. It should embody accurate dimensions and alignment of flanged or threaded openings, etc., plus qualified welding conforming to codes and insurance requirements.

Department of Novel Solutions to Heating, Piping, and Air Conditioning Problems . . . I

● *The Editors of HPAC will welcome contributions to this department, which will be paid for at regular rates. Needless to say, further use of information published under the above title is not recommended.*

I WAS sitting in a barber shop in a small southern town, waiting to have my ears moved down, and overheard the barber and his customer discussing a problem involving heat and moisture. The barber explained that his house was heated with small gas fired room units, and that they caused a lot of condensation on the inside of the windows.

"Yes," said the customer, "my brother has the same trouble, and here's what he's doing. The gas heaters take oxygen out of the air and that causes moisture to form on the windows. The only way to make up for that oxygen is to put a water pan on the top of each heater. My brother has a water pan on every heater in his house, but they don't give out enough oxygen and he still gets a lot of water on the windows. It's a pretty big house, so he's going to put two pans on every heater and that is sure to stop the condensation on the windows."—*C.S.P.*

FUEL OIL and other fuel users have done a lot of things to meet the problems of rationing and restrictions in order to conserve heat. The one that appealed to me for simplicity, though, was that employed by a woman in Washington, D. C., who solved her difficulties—or, at least for awhile, she thought she had—by the following expedient:

She took a small cardboard box, lined it with Kleenex for insulation, and mounted it as an enclosure around the room thermostat. That kept the thermostat from getting cold, calling for heat, and using oil "unnecessarily."—*J.H.C.*

POSTWAR CONSTRUCTION

A 32-page analysis entitled, *Potentials — Postwar Prospects and Problems — a Basis for Action*, has just been issued by the F. W. Dodge Corp., New York, N. Y. This analysis is the work of the company Committee on Postwar Construction Markets and contains many sections which will be of interest to the heating, ventilating and air conditioning engineer, as will be evident from an inspection of the chapter titles, some of which are: Nature of Construction Demands, Postwar Construction Volume, Private Construction Demand, Urban Re-development, Public Housing, and Will Construction Expand After Deferred Demands Have Been Met?

* * *

All-out conservation is a vital contribution to the war effort. Do all you can to save coal, oil, gas, electricity, water, transportation, and communication facilities.

Heating, Piping & Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

M. F. Blankin
Philadelphia, Pa.

Society Holds 50th Annual Meeting in New York

Hotel Pennsylvania
January 31
February 1-2
1944

THE 50TH Annual Meeting of the Society is now a matter of history and it will be vividly remembered by everyone who was present at the Hotel Pennsylvania, New York, January 31 to February 2. Several of the Society's previous records were shattered as the membership now stands at an all-time high; the registration reached the remarkable total of 920, of which 540 were Society members, or nearly one-sixth of the membership, 258 were guests, and 122 ladies and there were 19 of the 23 living past presidents in attendance.

Congratulatory messages were presented by representatives of 25 organizations at the opening session, and a number of committee reports were received.

For the opening luncheon on Monday, nearly 500 members and ladies assembled to hear the Honorable F. H. LaGuardia, Mayor of the City of New York, speak on the subject of Post War Era Offers a Challenge to Engineering. The Mayor outlined the city's post war plans which will provide employment for 200,000 and he emphasized the fact that New York is further advanced on its post war planning program than any other City, State or the Federal Government. The mayor indicated that the program would include schools, hospitals, courts, police and fire stations, sewage disposal facilities, playgrounds and street and highway improvements. Mayor LaGuardia told his audience that the city wanted to have the last word in heating and ventilating, cleaning and sanitary appliances, and he also indicated that it was up to the engineers who have been creating things to insure the success of the public works program after, as it can't be done by amateurs, nor by lawyers or professional politicians.

The first session was opened at 9:30 a. m., Monday, January 31, by Pres. M. F. Blankin, who presented the distinguished guests who delivered anniversary messages and greetings. He announced the personnel of the Resolutions Committee, R. A. Folsom, San Francisco, H. B. Hedges, Philadelphia, and William Glass, Winnipeg.

President Blankin reported that the Council were unanimous in endorsing the petition nominating Dr. W. H. Carrier, Syracuse, N. Y., and Dr. Arno C. Fieldner, Washington, D. C., for election as Honorary Members of the Society. He briefly reviewed the distinguished careers of the candidates and on motion of Alfred J. Offner, New York, seconded by T. T. Tucker, Atlanta, it was unanimously voted that Dr.

W. H. Carrier be elected an Honorary Member of the Society. On motion of Thornton Lewis, Washington, D. C., seconded by W. A. Russell, Kansas City, it was voted that Dr. Arno C. Fieldner be elected an Honorary Member of the Society.

President Blankin gave his report on the present condition of the Society and reviewed the various important actions taken by Council during the year. (Report to be published in March Journal.)

W. A. Russell presented a summary of the Report of the Chapter Development Committee, in which he outlined the four matters assigned for study relating to Society and Chapter relationships. He said that the Committee has held three meetings and had submitted its full report in advance, to all members of the Society.

Paul D. Close, chairman of the Guide Publication Committee, gave his report and stated that because of war time paper conservation measures no expansion of the Guide text was feasible. He described the important changes and additions which had been made and said that as in the past The Guide represented well established practice in the field of heating, ventilating and air conditioning. Distribution of the book is scheduled to begin February 28.

R. A. Wasson, chairman of the Board of Tellers, presented the results of the ballot for officers and members of the Committee on Research as follows:

Ballots for Officers

Total Ballots received.....1020
Total Legal Ballots.....1002
President—S. H. Downs.....1000
1st Vice-President—C.-E. A. Winslow 998
2nd Vice-President—Alfred J. Offner. 999
Treasurer—L. P. Saunders.....1002
Members of Council (three-year term)
C. M. Ashley..... 999
L. T. Avery..... 998
L. E. Seeley..... 998
G. D. Winans.....1001
(Scattering votes for other candidates.)

Ballots for Committee on Research

Total Ballots received.....1020
Total Legal Ballots.....1002
Three-Year Term:
C. M. Ashley..... 999
F. E. Giesecke.....1002
F. C. McIntosh.....1001
G. L. Tuve.....1002
T. H. Urdahl.....1001
Two-Year Term:
John James 999
(Scattering votes for other candidates.)

The Monday afternoon session was opened with First Vice-President S. H. Downs presiding. C. M. Ashley, chairman of Committee on Research, gave his report which is printed on page 101 of this issue.

L. T. Avery, chairman of the Committee on Constitution and By-Laws, presented the amendments to the Research Regulations which were discussed briefly and approved.

E. K. Campbell, treasurer, gave a statement of the finances of the Society and stated that the certified public accountants report covering the new fiscal period would be published.

Because of the unavoidable absence of S. R. Lewis, Chicago, past president of the Society, the paper, The Theories and Practices of the Past Fifty Years in Heating and Ventilation (complete paper published in Journal Section, HEATING, PIPING AND AIR CONDITIONING, January, 1944), was presented by John Howatt, Chicago.

The next paper was a Review of the Development of Standards for Comfort Air Conditioning, by Lt.-Comdr. F. C. Houghten.

After a few minutes recess First Vice-President Downs announced the panel discussion on the subject of The Future Trends of Heating, Ventilating and Air Conditioning. The members of the Panel were introduced by Chairman B. M. Woods as follows: D. M. De Bard, Washington, D. C., W. H. Driscoll, Syracuse, N. Y., C. E. Lewis, Rochester, N. Y., L. T. Mart, Kansas City, Mo., and Comdr. T. H. Urdahl, Washington, D. C.

(The Proceedings of the Meeting will appear in March.)

HONORARY MEMBERS

On January 31, 1944, the American Society of Heating and Ventilating Engineers conferred Honorary Membership upon Dr. Willis H. Carrier, Syracuse, N. Y. He is chairman of the board of Carrier Corporation, a native of New York State and a distinguished alumnus of Cornell University. In 1911 he announced the Carrier Psychrometric Theory and since that time he has established a world-wide reputation in the field of research, invention and development associated with the arts and sciences of heating, ventilating and air conditioning.

His work has been acclaimed and he has received many honors from engineering and scientific societies. He is a past-president of the ASHVE and has been active in many other engineering organizations.

W. H. Carrier

A. C. Fieldner

The American Society of Heating and Ventilating Engineers conferred Honorary Membership upon Dr. Arno C. Fieldner, Chief, Fuels and Explosives Service and Chief Engineer, Coal Division, Bureau of Mines, Dept. of the Interior, Washington, D. C.

Dr. Fieldner is outstanding in the field of fuel research and has received many honors in both this country and abroad for his work and is active in many professional and scientific societies.

For a period of 25 years Dr. Fieldner has been closely cooperating in the research work of the Society as a member of the staff of the United States Bureau of Mines. He has given great encouragement to the development of our Research and has contributed much to the success of our work.

Committee on Research Annual Report 1943

Twenty-five Years of Research

This year the Society completed 25 years of research and, whilst today the research activities of the Society are the accepted order of things, 25 years ago they were a radical innovation.

The Research Laboratory was officially instituted on August 1, 1919, under Dean John R. Allen as director. It was located in the Bureau of Mines Building in Pittsburgh, Pa., with a staff of three, one of whom was on the payroll of the Bureau of Mines. The constant temperature room, located in the basement of the Bureau of Mines building, in which so many of the Society's studies on the effect of environmental conditions on man have been conducted, was completed during 1920.

The first cooperative contract was also established in 1919 at the University of Minnesota. For those who know the long distinguished and continuing research record of Prof. F. B. Rowley, it is not surprising that the work was carried on under his direction. The study was concerned with radiant heat losses from direct radiators.

During the past 25 years research has been carried on at the Laboratory on a wide range of subjects; paralleling this has been the work of the Committee on Research, the many technical advisory committees, and work at a large number of cooperating institutions. These all complete a picture of research activity which has contributed much to the growth and present stature of the Society and of the Industry.

IN COMMON with most similar organizations, the activities carried on by the Research Committee have, of necessity, been curtailed due to the diversion of attention and personnel caused by the war effort. As a result a number of the Technical Advisory Committees were relatively inactive and the cooperative research at universities was sharply curtailed. The Society is under a debt of gratitude to Professor Humphreys for adding to the burden of his normal teaching duties at Carnegie Institute of Technology, the part-time direction of the activities at the Research Laboratory.

The chief accomplishments of the Committee on Research during the past year have been in the field of organization and plans for the future. Early in the year plans were formulated looking not only toward bringing the research activity back to its former rate, but also increasing the scope and magnitude of the research operations. These plans visualized the following specific steps:

1. Secure a Director of Research for the Society who would give his full time and attention to the research activity of the Society, and who would be in administrative charge of all of the research activities, including both those at the laboratory of the Society and those carried on in cooperating institutions.
2. Propose amendments to the Regulations under which the Research Committee operates so as to permit more efficient administration.
3. Secure a new home for the research laboratory of the Society which would provide adequate facilities and room for future expansion, in keeping with the great possibilities of the Society's research program.
4. Augment the laboratory staff commensurate with the enlarged program.
5. Develop a long-range program of research, oriented primarily to the needs of the Industry and engineering profession served.
6. Encourage the more extensive participation of Industry in the research program through both financial contributions and program recommendations.
7. Enlarge the cooperative research activity carried on by the universities as their facilities permit.
8. Encourage the coordination of all the technical activities of the Society.

The first three steps of this program have already been taken. On October 1, Mr. Cyril Tasker became Director of Research. The effect of his vigorous leadership is already evidenced in the quickened tempo of the interest and activities of the Research Committee. Announcement has been made of the plans for the new research laboratory which, it is believed, will serve as the cornerstone of a greater research structure. At this meeting you are being asked to approve proposed amendments to the Regulations Governing the Committee on Research.

Much still remains to be done to consummate the other steps of the plan, but here also the ground work has been laid. The Research Committee believes that we are well on the way toward the realization of the latent potentialities existing in the program as visualized.

During the year, two research programs being conducted on behalf of the U. S. Navy Department were successfully completed. One of these having to do with physiological reactions was carried on at the Society laboratory, while the second concerning coil performance was conducted at Case School of Applied Science. Members of the Society can take some satisfaction not only in the creditable work done, but also in the fact that the facilities and basic staff of the Society laboratory were contributed gratis for the program. While the research work both of the laboratory and of the cooperating institutions was considerably restricted, there were signficant contributions to basement heat loss, air distribution, filter performance, cooling tower performance, psychrometric properties, panel heating, heat gain through sunlit walls, etc. Much significant work was done during the year which has not yet been published. Eleven cooperative research projects were active; three meetings of the Research Committee were held; five meetings of the Research Executive Committee; twenty-eight meetings of the Research Advisory Committees.

The financial highlights of the research operations for the period ending October 31, 1943, are as follows:

Total Income	$46,840
Total Expenses	37,850
Excess of Income over Expenses	8,990

The Income was made up of:

Dues from members and associate members	16,900
Special Council Appropriation	5,000
General Contributions	5,790
Earmarked Funds (Principally from U. S. Navy)	19,150

The Expenses were made up of the following:

Payments directly to cooperating institutions	6,200
Navy projects carried on at the Pittsburgh Laboratory and at Case School of Applied Science	19,000
Other projects carried on at Pittsburgh Laboratory	3,260
Expenses apportionable to the Laboratory and cooperating institutions	9,390

Included in the published report will be summary reports of the work of the individual Technical Advisory Committees. The resurgence of interest shown by these important committees in the research work of the Society is evidenced by the record number of Technical Advisory Committee workings, 17 being held at the present session.

Technical Advisory Committees

Sensations of Comfort

Thomas Chester, *Chairman;* N. D. Adams, C. R. Bellamy, G. D. Fife, E. P. Heckel, F. C. McIntosh, A. B. Newton, B. F. Raber.

Though no laboratory investigations were possible under this Committee during the year, the opportunity was taken to commence the re-study and tabulation of data collected at Minneapolis in 1937. These studies dealt with the general reactions of a large number of office workers to summer cooling and air conditioning and their shock experiences after entering and leaving cooled and air conditioned offices and the general findings were published in the 1938 Transactions.

Some 25,000 cards collected at that time are being analyzed, with the aid of a tabulating machine, under the direction of Professor Rowley at the University of Minnesota. Mr. Newton who conducted the original tests is assisting in the work. The cards are being sorted and correlations made between the more important combinations of the following variables:

a. Feeling of comfort (scale ranges from uncomfortably cold to uncomfortably warm).
b. Variation in feeling of comfort at various periods of the day.
c. Dry-bulb temperature of the conditioned space.
d. Relative humidity of the conditioned space.
e. Effective temperature of the conditioned space.
f. Age of the subject reporting reactions.
g. Sex of the subject reporting reactions.
h. Outdoor dry-bulb temperature.
i. Outdoor relative humidity.
j. Work zone.

From these tabulations correlations will be made between such variables as age and comfort, effective temperature and comfort upon entering the conditioned space, effective temperature and comfort reactions after continued exposure in conditioned space, relative humidity and comfort reactions, etc. The exact course of the project can be determined only after some of the initial investigations have been made.

Some of the studies conducted for the U. S. Navy Department developed data of interest to this Committee but its import cannot, of course, be made available at this time and will await release by the naval authorities.

Physiological Reactions

R. W. Keeton, *Chairman;* Thomas Bedford, A. R. Behnke, A. C. Burton, E. F. DuBois, A. W. Eyer, A. P. Gagge, F. C. Houghten, A. C. Ivy, R. R. Sayers, Charles Sheard, A. D. Tuttle, C.-E. A. Winslow.

Important government research assignments at the College of Medicine of the University of Illinois in Chicago have prevented a full time resumption of the studies which were discontinued in October, 1942, and are not likely to be renewed until conditions are materially changed. A report covering observations on the physiological adjustments of subjects passing from a hot to a comfortable environment was made to the Committee at the end of the year by Dr. Keeton and his colleague, Mr. Glickman. Dr. R. W. Keeton, the Chairman of the Committee, revised Chapter 37 of The Guide dealing with Air Conditioning in the Treatment of Disease.

Numerous studies on the effect of environmental conditions on the physiological reactions of the human being have been and are being made for the Armed Services of all the allied nations. This work, which cannot be made public now, will eventually add tremendously to our knowledge of this subject and it will be the function of this Committee to interpret the results for the Society membership and the general public. Some of the Committee met informally in Chicago in November and commenced the formulation of plans for studies at the Society's research laboratory and at cooperating institutions. The Committee expressed the opinion that the Society should continue its studies into the physiological reactions of human beings to environmental conditions as soon as conditions allowed and staff were available. The Committee also expressed the need for wider publication of the Society's work particularly in journals read by the medical profession and physiologists.

Removal of Atmospheric Impurities

R. S. Dill, *Chairman;* J. J. Burke, J. M. Dalla Valle, Leonard Greenburg, Theodore Hatch, W. C. L. Hemeon, L. R. Koller, C. A. McKeeman, F. H. Munkelt, H. C. Murphy, G. W. Penney, E. B. Phelps, F. B. Rowley, G. H. Schember, J. B. Smith, W. O. Vedder, J. H. Waggoner, R. P. Warren, W. F. Wells.

Work has continued under this Committee under a cooperative agreement with the University of Minnesota where Prof. F. B. Rowley and his colleagues have been studying problems connected with the testing of air filters.

A paper entitled, Discoloration Methods of Rating Air Filters, is being presented by F. B. Rowley and R. C. Jordan at the 50th Annual Meeting of the Society. In this paper the authors present, in addition to a review of the principal photometric methods used in testing air filters, a new method of determining the true discoloration efficiency of air filters; they also analyze the theory of discoloration. They introduce the term *value* in order to take into consideration the psychological and physiological reactions of the human eye in interpreting discoloration.

In the latter part of the year the air filter research equipment described in previous reports has been relocated and some changes in design made. A special air filter research room has been constructed and improvements incorporated, which have resulted from past experience. Recent investigations were mainly concerned with the air-pressure gradients through filters and it is expected that a paper covering this phase of the work will be presented at the next Semi-Annual meeting of the Society.

Radiation and Comfort

J. C. Fitts, *Chairman;* E. L. Broderick, R. E. Daly, L. N. Hunter, F. W. Hutchinson, A. P. Kratz, John James, C. S. Leopold, D. W. Nelson, G. W. Penney, W. R. Rhoton, T. H. Urdahl.

Though exploratory tests to serve as a guide for future research under this committee were planned for the Research Laboratory for 1943, pressure of the Navy work prevented their being made in the winter months. Future work under this Committee is to a marked extent dependent on some satisfactory solution of the problem of instrumentation with regard to the measurement of radiant heat; to this end the Committee is meeting jointly with the Technical Advisory Committee on Instruments, at the 50th Annual Meeting, to plan a laboratory and field attack on this problem.

An important and fundamental investigation was made under this Committee during 1943 at the University of California, Berkeley, Calif., where Profs. B. F. Raber and F. W. Hutchinson are studying the effect of radiant interchange on comfort. Their second progress report on the work is being presented in the form of a paper entitled "Optimum Surface Distribution in Panel Heating and Cooling Systems," at the 50th Annual Meeting of the Society.

Work is in progress at California to investigate the re-

tionship between the air temperature and surface temperature in a panel heated room and to establish the magnitude of air temperature depression (below MRT) which is thermally possible in a room heated with low temperature ceiling panels.

Instruments

D. W. Nelson, *Chairman;* L. M. K. Boelter, E. L. Broderick, R. S. Dill, R. B. Engdahl, A. P. Gagge, J. A. Goff, J. D. Hardy, A. E. Hershey, F. W. Reichelderfer, G. L. Tuve, C. P. Yaglou.

Though no work has been carried out directly under this Committee during the past year, some studies having a close bearing on it were undertaken at the Research Laboratory when the Navy work had been completed, whilst at the University of Illinois and at the University of California studies on instruments formed part of larger and more comprehensive investigations. Most instrumental development work is carried on as an integral part of some research project for which adequate instruments are not available; it is not generally practicable or easily possible for the instrumentation for a project and the project itself to be separated.

There is a great need for the standardization of both Laboratory and field instruments for the measurement of mean radiant and low air velocities. Many field studies give inconclusive results because of difficulties in the interpretation of the results of some of the measurements made. Considerable attention to this subject is proposed for the Society's research laboratory in the near future.

Weather Design Conditions

T. H. Urdahl, *Chairman;* J. C. Albright, H. S. Birkett, P. D. Close, J. F. Collins, Jr., John Everetts, Jr., C. M. Humphreys, H. H. Koster, J. W. O'Neill, F. W. Reichelderfer.

It has not been possible to resume actively the work of this Committee during the past year. The subject has, however, become of considerable interest in connection with fuel saving and the data which are now being collected in many parts of the country are much more complete than was collected before the war. It is intended during the coming year to commence work on the preparation of weather design data of use to the design engineer by an analysis of data collected some years ago and on which a preliminary analysis was done under governmental agencies.

Radiation with Gravity Air Circulation

M. K. Fahnestock, *Chairman;* R. E. Daly, R. S. Dill, A. G. Dixon, F. E. Giesecke, H. F. Hutzel, J. P. Magos, J. W. McElgin, J. F. McIntire, W. A. Rowe.

During the past year the active work of this Committee was carried on in the warm wall test booths in the Engineering Laboratories of the University of Illinois. The work included the following studies, each made with one small-tube type of direct cast-iron radiator, one cast-iron convector with end and bottom connections, one non-ferrous convector with end connections, and one non-ferrous convector with bottom connections.

1. Heat Output Studies With:
   a. Water at different velocities or temperature drops through the units.
   b. Water at different entering and mean temperatures.
   c. Steam and water at the same mean temperatures.
2. Fluid Pressure Loss or Frictional Resistance Studies With:
   a. Top and bottom end connections to the radiator.
   b. End and bottom connections to the cast-iron convector.
   c. End connections to one non-ferrous convector and bottom connections to another non-ferrous convector.

   (All units were tested with the connections made of two sizes of pipe.)

The work was made possible by obtaining the temporary services of Dr. F. E. Giesecke, who is on retirement from the Agricultural and Mechanical College of Texas. A preliminary report covering a portion of this work and entitled, Friction Heads in Radiators, Convectors, and Pipes, by Dr. F. E. Giesecke was given to the members of the Committee under date of March 2, 1943. The results of the completed work are available for a technical paper to be presented at the Summer Meeting of the Society in 1944.

Heat Transfer of Finned Tubes with Forced Air Circulation

W. E. Heibel, *Chairman;* William Goodman, H. F. Hutzel, Ferdinand Jehle, S. F. Nicoll, R. H. Norris, L. P. Saunders, R. J. Tenkonohy, G. L. Tuve, D. C. Wiley.

A cooperative experimental program is being started at Case School of Applied Sciences for the study of evaporating Freon 12 refrigerant transfer inside horizontal tubes. It is hoped to enlarge this program later to take full advantage of the experience gained by the School in the Navy and other coil test programs. Among proposed future subjects of study are:

1. Heat transfer and air resistance of finned coils condensing moisture from the air.
2. The effect of fin and tube proportions on heat transfer, condensed moisture carryover and air resistance.
3. Correlation of experimental and theoretical fin heat flow resistance.
4. Preferred method of coil performance correlation and prediction.

Cooling Load in Summer Air Conditioning

W. E. Zieber, *Chairman;* John Everetts, Jr., W. F. Friend, R. H. Heilman, John James, C. S. Leopold, C. O. Mackey, A. E. Stacey, Jr., G. E. Tuckerman, J. H. Walker, M. J. Wilson.

A cooperative project under the direction of the Committee was initiated this year at Cornell University for the study by mathematical methods of the heat flow through walls due to temperature difference and sunlight. The present study takes advantage of mathematical methods previously developed under the sponsorship of the Pierce Foundation and reported at the 1943 Annual Meeting in a paper by C. O. Mackey and L. T. Wright, Jr., entitled, Summer Comfort Factors as Influenced by the Thermal Properties of Building Materials. The study is a continuation of the long-term experimental program which has been carried on at the Laboratory. It should result in a better knowledge of this important subject through better control of the many uncontrolled and unknown variables encountered in the experimental program.

The study this year dealt primarily with homogeneous walls. It is hoped to continue with the study of non-homogeneous walls and also to determine the storage effect of building mass with changing inside temperature. A progress report covering the work done this year has been presented to the Committee and is expected to result in a paper for the Semi-annual meeting.

Another phase of this project is the study of the normal summer air temperatures and solar radiation on which a paper is also expected for the Semi-annual meeting.

During the year a sub-committee was appointed consisting of John Everetts, Jr., Chairman, Capt. A. E. Stacey, Jr., and J. H. Walker to study and correlate the results of the experimental and mathematical work carried on under the auspices of the Committee on roofs and walls.

Study is also urgently needed on the subjects:

1. Infiltration through opened, swinging and revolving doors.
2. Heat load from appliances.
3. Heat load from lighting.

Air Distribution and Air Friction

J. H. Van Alsburg, *Chairman;* S. H. Downs, A. P. Kratz, E. C. Lloyd, R. D. Madison, L. G. Miller, D. W. Nelson, C. H. Randolph, L. P. Saunders, M. C. Stuart, Ernest Szekely, G. L. Tuve.

Though the activities of this Committee have been reduced and many of the research projects previously carried

Research Papers—1943

1. The Performance of Side Outlets on Horizontal Ducts, by D. W. Nelson and G. E. Smedberg (Wisconsin) (November, 1942, Journal).
2. Spray Nozzle Performance in a Cooling Tower, by L. M. K. Boelter and S. Hori (California) (May, 1943, Journal).
3. Final Values of the Interaction Constant for Moist Air, by John A. Goff, J. R. Andersen and S. Gratch (Pennsylvania) (June, 1943, Journal).
4. Discoloration Methods of Rating Air Filters, by Frank B. Rowley and Richard C. Jordan (Minnesota)(September, 1943, Journal).
5. Optimum Surface Distribution in Panel Heating and Cooling Systems, by B. F. Raber and F. W. Hutchinson (California) (November, 1943, Journal).
6. Control of Air-Streams in Large Spaces, by G. L. Tuve and G. B. Priester (Case) (January, 1944, Journal).
7. Physiological Reactions Applicable to Workers in Hot Industries, by F. C. Houghten, Carl Gutberlet and M. B. Ferderber (April, 1943, Journal). (Research Laboratory.)
8. Review of the Development of Standards for Comfort Air Conditioning, by Lt. Comdr. F. C. Houghten.

out under its direction have been temporarily discontinued, it was found possible to conduct one project at Case School of Applied Science where results of tests with about 45 sizes and kinds of non-directional discharge outlets were correlated with data from other investigations. This work was reported in a paper presented at the 50th Annual Meeting of the Society by G. L. Tuve and G. B. Priester and was entitled, The Control of Air Streams in Large Spaces.

Heat Requirements of Buildings

P. D. Close, *Chairman;* E. K. Campbell, J. F. Collins, Jr., E. F. Dawson, W. H. Driscoll, H. H. Mather, H. K. McCain, M. W. McRae, C. H. Pesterfield, F. B. Rowley, R. K. Thulman.

The basement heat loss study in the simulated basement on the premises of the Bureau of Mines at Pittsburgh was continued during the year, adding to the data presented in the original paper, Heat Loss Through Basement Walls and Floors, presented in 1942. Some additional data were obtained on the effect of insulation on heat loss in winter and condensation in summer. Unfortunately the set-up and the ground around it was unavoidably disturbed, thus largely nullifying the value of the later tests. It is believed that additional data of value might be obtained by extending the studies to actual basements and ground floors.

During the year the Committee gave consideration to the problem of exposure factors and found a wide range of opinions as to their value. Prevailing opinion held them unnecessary to increase overall estimated heat loss but of some value in balancing heat supplied to exposed and shielded rooms.

Problems of interest for future study appear to be:

1. Overall infiltration, particularly when considering type of heating system, fireplaces used, etc. Interest arises out of the wide diversity of opinion as to the proper basis for estimating infiltration.
2. Reconciliation of building heat loss with seasonal heating requirements.

Two papers relating to the activities of the Committee have been prepared by the Chairman, one "Graphical Method of Calculating Heat Losses" was presented at the summer meeting and the other is "A Rational Basis for Selecting Winter Design Temperatures."

Air Conditioning Requirements of Glass

R. A. Miller *Chairman;* L. T. Avery, F. L. Bishop, W. A. Danielson, H. C. Dickinson, J. D. Edwards, J. E. Frazier, E. H. Hobbie, C. L. Kribs, Jr., Axel Marin, F. W. Parkinson, W. C. Randall, L. E. Seeley, L. T. Sherwood, J. T. Staples, H. B. Vincent, G. B. Watkins, F. C. Weinert.

Since the Committee decided not to attempt any detailed research program during the war unless a special need arose, it has not been very active during 1943. It is expected to become active in 1944 since some earmarked funds are available for studies contemplated with the idea of obtaining additional data on the subject of window shades to satisfy the questions which have been raised about the present data.

The subject of infiltration is one which has attracted considerable attention in the last year or so because of government publicity in connection with methods of fuel saving. It is of some interest to this Committee and a program of research is contemplated.

Sound Control

R. D. Madison, *Chairman;* W. W. Kennedy, V. O. Knudsen, C. H. Randolph, A. E. Stacey, Jr., A. G. Sutcliffe, T. A. Walters, R. M. Watt, Jr.

The cooperative experimental program for the study of sound attenuation in ducts, elbows, outlets and splitters which was started at Rensselaer Polytechnic Institute in 1940 was at a standstill during the year. It is hoped to conclude it after the war. In addition the Committee is considering suggestions for study of:

1. Generation of noise by mechanical equipment and its measurement.
2. Room noise level problems including the introduction of noise through outlets, walls and floors, the direct generation of noise by equipment in the room and the effect of the characteristics of the room on the noise.
3. Desirable noise level limits including a study of the annoying effect of certain types of noise.

Cooling Towers, Evaporative Condensers and Spray Ponds

H. B. Nottage, *Chairman;* C. F. Boester, W. W. Cockins, S. C. Coey, E. H. Kendall, E. R. Ketchum, S. R. Lewis, J. F. Park, S. I. Rottmayer, E. W. Simons, E. H. Taze.

The past year has seen no basic changes in either the scope or direction of the cooperative research program under way at the University of California. The experimental program has been concerned with the announced current objective of obtaining performance and design data on point-to-point conditions within a slot-packed, mechanically-induced-draft cooling tower.

Based upon experimental work conducted during 1941-1942, a paper entitled, Spray Nozzle Performance in a Cooling Tower, was presented at the Semi-annual Meeting of the Society at Pittsburgh, in June, 1943, by L. M. K. Boelter and S. Hori. This was the second in a series dealing with spray tower performance.

Progress on the experimental program at the University of California has been summarized in a special illustrated report prepared under the direction of Professor Boelter. (A copy is available on loan to specially interested parties.) This report deals primarily with the development of transfer conditions throughout all parts of the full-scale experimental induced-draft cooling tower. These instruments represent essential original contributions to cooling tower studies. Preliminary test data have shown their value in the analysis and understanding of conditions within a cooling tower.

Further analysis of the spray tower data is being undertaken at the University of California.

The Chairman undertook the review of Chapter 27 of THE GUIDE, dealing with Spray Equipment.

Psychrometry

J. A. Goff, *Chairman;* F. R. Bichowsky, W. H. Carrier, H. C. Dickinson, R. S. Dill, A. W. Gauger, William Goodman, A. M. Greene, Jr., L. P. Harrison, F. G. Keyes, A. P. Kratz, D. M. Little, Axel Marin, D. W. Nelson, W. M. Sawdon.

The activities of the Committee for the past year have been concerned with the revision of Table 6 of THE GUIDE. To that end a paper, "Final Values of the Interaction Constant for Moist Air," was presented at the Semi-annual Meeting of the Society in Pittsburgh on June 7, 1943. This paper reports the experimental results of the cooperative investigation sponsored by the Society at the Towne Scientific School, University of Pennsylvania.

At the semi-annual meeting of the Society the Committee held a meeting in which it was decided to recommend to the Guide Publication Committee that the proposed revision of Table 6 for the range —100 to +200 F be accepted for publication.

The proposed revision of Table 6 has not yet been completed, since it was found that available data on B_{ww} (the second virial coefficient of water) were not sufficiently reliable, necessitating a careful review of the literature, in particular the low pressure steam properties published by the Bureau of Standards, 1939, in the light of modern statistical mechanical theory. This review is not yet complete but it seems that B_{ww} can be inferred from the above data with sufficient reliability.

At the meeting of the Committee on June 7 there was some discussion as to the proper graphical representation of the data of Table 6 and those discussions have continued between members of the Committee.

The future activities of the Committee are immediately concerned with completion of the revision of Table 6, and with the possibility of preparing tables similar to Table 6 but for pressure other than atmospheric.

New knowledge of the thermo-dynamic properties of moist air which it is expected will be characterized by a high degree of accuracy will, it is felt, emphasize the need for the development of a suitable dew-point or other apparatus having considerable accuracy.

Flow of Fluids Through Pipes and Fittings

F. E. Giesecke, *Chairman;* T. M. Dugan, S. R. Lewis, L. P. Saunders.

During the year the Chairman completed the manuscript for a bulletin, to be issued through the Engineering Experiment Station of Texas Agricultural and Mechanical College, entitled, Friction Heads in Six-Inch Pipe and the Effects of Pipe Surface Roughness and of Temperature on Friction Heads. This bulletin contains, among other data, that published in the ASHVE Journal Section in November 1942.

For future research the following problems have been suggested:

1. How does thermal circulation of water take place in a vertical pipe?
2. To what extent is the friction in a stream of water flowing in a pipe affected by a turbulence created at the end of the pipe or at some point in the pipe? For example, by a pipe fitting, or a valve, or an orifice, or a pump.
3. To what extent is the friction of a stream of water flowing in a pipe affected by the transfer of heat from the stream of water to the enclosing pipe wall or from the enclosing pipe wall to the stream of water?

Fuels

R. A. Sherman, *Chairman;* R. M. Conner, R. S. Dill, R. B. Engdahl, A. C. Fieldner, L. N. Hunter, S. Konzo, W. M. Myler, Jr., H. J. Rose, C. E. Shaffer, T. H. Smoot, R. K. Thulman, T. H. Urdahl, E. C. Webb.

This Committee has been badly hampered in carrying out its projected program, drawn up at the 49th Annual Meeting of the Society because of the lack of competent personnel that could be spared from other duties, mostly in connection with the Navy studies at the Research Laboratory. Work on a projected program on chimneys had to be postponed to a more favorable time but it is hoped that an active program will be in operation in the near future. A ballot was conducted among members of this Committee late in the year in an effort to select projects to be recommended to the Research Committee for investigation. Among the projects calling for early attention were the following:

1. Fundamental and comprehensive investigation of factors governing the performance of chimneys.
2. Investigation of the performance of barometric dampers on residential heating equipment.
3. Methods for the measurement of flue-gas temperatures in heating equipment.
4. Methods for the measurement of the temperature of metal and other surfaces in heating equipment.
5. Investigate the relation of the heating requirement of buildings and the required boiler output.

Bituminous Coal Research Inc. has on its project agenda an investigation of chimneys and it is expected that cooperation will be arranged on this project.

In December a preliminary report was made to the Committee by a sub-committee set up to prepare criteria for fuel burning heating equipment. The report served to point out the fundamentals of the problem, the need for close cooperation between the heating industry and the insulation industry in achieving a satisfactory thermal environment, and the need for the standardization of methods of calculating heat losses from a structure, particularly as regards infiltration losses.

One of the members of the Committee, R. S. Dill, was responsible for revising Chapter 9 of The Guide, which deals with chimneys and draft calculations. Another member, S. Konzo, was also a member of The Guide Publication Committee.

Corrosion

L. F. Collins, *Chairman;* R. C. Doremus, E. W. Guernsey, G. G. Marvin, A. R. Mumford, L. P. Saunders, F. N. Speller.

Officially, the research studies being conducted under a cooperative agreement at Carnegie Institute of Technology, Pittsburgh, were concluded in September. These studies were aimed at revealing the mechanism by which carbon dioxide entrained by steam becomes dissolved in the condensate formed in heating equipment. Because of obstacles imposed by the war, the work consumed much more time than was contemplated. In September, Dr. McKinney and his coworkers were not entirely satisfied with the results and elected to carry on at their own expense for an additional period. They have now completed the work and are preparing a report which will be submitted to the Committee at the 50th Annual Meeting. It is felt that this work has produced some usable results.

The Chairman presented a paper before the Fourth Annual Water Conference of the Engineers Society of Western Pennsylvania, held at Pittsburgh, in November, entitled, More Information Concerning Corrosion in Steam Heating Systems.

The Committee has been asked to consider an extension of the scope of its program, which has heretofore been mainly concerned with corrosion in steam heating systems, so as to cover the extremely divergent corrosion problems encountered by the many branches of the air conditioning industry.

Air Conditioning in Industry

W. L. Fleisher, *Chairman;* L. T. Avery, A. R. Behnke, Leonard Greenburg, W. E. Heibel, F. C. Houghten, D. E. Humphrey, E. F. Hyde, L. L. Lewis, P. A. McKittrick, R. R. Sayers, R. M. Watt, Jr., H. E. Ziel.

Though this Committee laid plans for an extensive program of laboratory and field studies in various industries where hot and humid conditions are encountered, lack of trained personnel and funds prevented the program from being carried out during the past year.

The Committee is meeting in New York at the 50th Annual Meeting to consider:

1. The examination and analysis of existing laws and ordinances as issued by various organizations interested in industrial hygiene.
2. The re-examination of laboratory data on the effect of hot environments on man.
3. The collection of data in the field on the effect of environmental conditions on output and fatigue of workers.

Sorbents

F. R. Bichowsky, *Chairman;* O. D. Colvin, F. Dehler, John Everetts, Jr., Ralph Fehr, J. A. Goff, W. R. Hainsworth, C. H. B. Hotchkiss, J. C. Patterson, G. L. Simpson.

This Committee is still somewhat new and without a fully organized program. It was formed to correlate and extend the data concerning both adsorbent and absorbent materials, processes and utilization. At a meeting coincident with the 1944 Annual Meeting of the Society it is hoped to develop a specific program along the lines of:

1. Chemical and physical properties and characteristics of sorbents.
2. Equipment and methods of application.
3. The fields of economical application of sorbents.

Insulation

E. R. Queer, *Chairman;* J. D. Edwards, F. G. Hechler, H. K. McCain, Paul McDermott, W. T. Miller, H. C. Robinson, F. B. Rowley, G. L. Tuve, J. H. Waggoner, G. B. Wilkes.

The committee accomplished the following work:

1. A review was made of data from various sources bearing on the subject of upward heat flow in mineral wool

Institutions Cooperating with the Committee on Research

Carnegie Institute of Technology

Corrosion in steam heating systems.

Case School of Applied Science

Air distribution in air conditioned spaces.

Cornell University

Heat flow through building walls.

Georgia School of Technology

Cooling of a structure with attic fans.

Oregon State College

Heat transfer through wetted walls.

University of California

Performance of Cooling Towers.
Radiant Heating and Cooling.

University of Minnesota

Methods of testing air cleaning devices.
Statistical study of reactions of office workers to environmental conditions.

University of Pennsylvania

Measuring departures from Dalton's Law of Air-Water vapor mixtures.

Contracts at the following institutions were in force, but were inactive during 1943: Agricultural and Mechanical College of Texas, Lehigh University, Rensselaer Polytechnic Institute, University of Illinois (College of Engineering and Medical School), and the University of Wisconsin.

insulation and the possible effect of convection currents on such heat flow. The conclusions of the sub-committee were that the available data and information do not indicate that any change in the conductivity value of 0.27 for mineral wool as now listed in the 1943 Guide, is necessary or desirable for estimating purposes. The effect of any wooden joists or other building members in such a position as to affect the flow of heat through the insulating material should be taken into account. One of the most important phases of independent tests, with and without paper over the exposed surface of the mineral wool, showed no effect due to the paper covering that was not within the limits of experimental error.

2. It is the opinion of this Committee that it is desirable to have insulation heat transmission coefficients under actual service conditions. The Office of Production, Research and Development (OP RD) of the WPB has an extensive research and testing program to determine the heat transmission performance under accelerated climatic conditions of materials used in economical housing. An arrangement has been worked out whereby these data will be made available to this committee with the thought of eventually using them in The Guide.

3. A sub-committee of ASTM C-16 under the chairmanship of R. H. Heilman is studying vapor barriers and the mechanism of vapor transmission. This committee as well as a member of the ASRE is cooperating in this study.

The additional work to be undertaken under this committee is:

1. A review of insulation coefficients in The Guide so as to bring them up to date. If found necessary tests should be made by the new standardized Guarded Hot Plate Test Method. A Standardized Guarded Hot Box Test Method should be developed for overall coefficients by the combined ASHVE, ASTM and ASRE committees.

2. Low temperature heat transmission values should be obtained for 10 in. and 12 in. thick walls.

Heavy Duty Air Furnaces

E. K. Campbell, *Chairman;* H. D. Campbell, K. T. Davis, A. P. Kratz, W. J. MaGirl, A. A. Olson, B. B. Reilly, H. J. Rose, H. A. Soper.

This committee was set up in the latter part of 1942 to analyze information on heavy duty furnaces with a view to determining whether sufficient data were available and whether a code committee was needed. The Committee reported in June that *although there are certain codes or tentative codes for furnaces of smaller output there is, at present, no generally recognized authority sponsoring a code covering the general field of heavy duty air heating furnaces.* They therefore recommended *that the ASHVE is the proper authority* and that the *Society should develop and adopt, for the public benefit, a code for testing and rating heavy duty air heating furnaces.*

At the November meeting of Council held in Indianapolis, authority was given for the appointment of a Code Committee.

Atlanta Chapter Advisory Committee

T. T. Tucker, *Chairman;* W. J. McKinney, Leo Sudderth.

Attic Fans

Work originally commenced in 1941 under a cooperative agreement between the Society and the Georgia School of Technology resulted in a paper given at the 48th Annual Meeting of the Society held in January 1942. This contract was renewed on a reduced scale in 1942, and was again renewed in 1943 without payment of any funds since the institution found itself unable to proceed at present with further experimental work.

A report covering the work completed in 1942 has been prepared by Professor Hinton and Mr. Wanamaker and approved by the Atlanta Chapter Committee. It is entitled, Some Effects of Attic Fan Operation on Comfort and is scheduled for presentation at the next Semi-Annual Meeting of the Society.

Contributors to Research

Financial Contributions

Aerofin Corp., Air-Maze Corp., The Harry Alter Co., Aluminum Co. of America, Auditorium Conditioning Co., Automatic Burner Corp., Automatic Products Co., Barber-Colman Co., Barnes & Jones, Inc., Bayley Blower Co., Bell & Gossett Co., Blue Ridge Glass Corp., Buffalo Forge Co., California Redwood Assn., E. K. Campbell Heating Co., Cutler-Hammer, Inc., Chase Brass & Copper Co., Inc., Chicago Pump Co., Chamberlin Metal Weather Strip Co., Crane Co., Calgon, Inc., Carrier Corp., Drayer & Hanson, Inc., The Dole Valve Co., Duquesne Light Co., Detroit Stamping Co., Lewis M. Ellison (In Memory of Albert O. Ellison), Lewis M. Ellison, M. A. Gerett Corp., The G & O Mfg. Co., Grant Wilson, Inc., Grinnell Co., Inc., The Fluor Corp., Ltd., Fedders Mfg. Co., Inc., The Fulton Sylphon Co., Forslund Pump & Machinery Co., The Heil Company, Heating, Piping and Air Conditioning Contractors National Association, Inland Steel Co., Illinois Engineering Co., Insulation Board Institute, Johnson Service Co., Johns-Manville, Kieley & Mueller, Inc., Monarch Mfg. Works, Inc., The Marley Co., Inc., Masonite Corp., May Oil Burner Corp., Modine Mfg. Co., John J. Nesbitt, Inc., Narowetz Heating and Ventilating Co., The Nash Engineering Co., National Lumber Manufacturers Association, The Plastergon Wall Board Co., A. G. Pratt, The Permutit Co., Perfex Corp., Portland Cement Association, Penn Lithographing Co., Pipe Fabrication Institute, Surface Combustion, Sheffler-Gross Co., The Sisalkraft Co., Spencer Thermostat Co., Subsidiary Companies of Bethlehem Steel Corp., Trade-Wind Motorfans, Inc., The Torrington Mfg. Co., Tempil Corp., The Timken-Detroit Axle Co., The Trane Co., Utility Fan Corp., U. S. Electrical Motors, Inc., Universal Power Corp., U. S. Gauge Co., Union Electric Co. of Missouri, Universal Cooler Corp., Vilter Mfg. Co., Watson & McDaniel Co., Williams Oil-O-Matic Heating Corp., Webster Electric Co., Weil-McLain Co., L. J. Wing Mfg. Co., Westinghouse Electric & Manufacturing Co., Wolverine Tube Division, Wright-Austin Co., York Ice Machinery Corp.

Periodicals

American Artisan, Combustion, Domestic Engineering, Fuel Oil and Oil Heat, Heating, Piping and Air Conditioning, Heating and Ventilating, Ice and Refrigeration, and the Journal of the Institution of Heating and Ventilating Engineers (London).

Oregon Chapter Research Advisory Committee

E. W. Neubauer, *Chairman;* J. E. Yates, W. J. Kollas, J. D. Kroeker, T. E. Taylor, E. C. Willey.

Heat Flow Through Wet Building Walls

Late in 1942 a cooperative agreement was signed between the Society and Oregon State College, Corvallis, Oregon, covering the investigation of heat flow through wet building walls to be carried on in the domestic heating laboratory of the College. The study was planned jointly by Prof. Earl C. Willey of the College and the research committee of the Oregon Chapter of the Society of which E. W. Neubauer of Portland is chairman. The plans called for the construction of various types of building wall sections and their testing under conditions simulating heat loss during rainy weather.

It was felt that the results of the investigation would be of particular interest for application in the Pacific Northwest in which building walls are wet during much of each winter season, since only incomplete information on heat loss through wet walls is available for accurate determination of heating plant requirements.

The contract was renewed in June 1943 for a further year. During the first year the work consisted mainly in reconstructing the original apparatus to take advantage of the information gained by the University of Minnesota Experiment Station in the operation of a hot box similar to the one to be used in these studies.

Like other institutions Oregon State College found itself too short of competent help to proceed as rapidly as had been planned and there is little likelihood of completing this project within the period covered by the contract. Sufficient data have been collected however to indicate the trend of the investigation which will be resumed at a more rapid tempo as soon as conditions permit.

The Axial Flow Fan and Its Place in Ventilation

By W. R. Heath* and A. E. Criqui,** Buffalo, N. Y.

THE FIELD of ventilation is finding a newcomer in its midst, in the axial flow fan. Competing as it does with the centrifugal fan in its use for pressure applications, the fan users' first question is, *When should I use an axial flow fan?* It is the purpose of this paper to point out the characteristics of the axial flow fan and to compare them with centrifugal fans, to provide a basis for answering this question.

Definition

Broadly speaking, the term *axial flow* is generic, indicating a fan in which the air flows parallel to the axis of the wheel, as opposed to radial flow as in the centrifugal fan. The term might thus be generally applied to desk fans, propeller fans, disk fans, etc., even up to turbine rotors. Among the engineering profession, however, it has come to mean specifically that type of axial flow fan of recent design which unfortunately bears no distinguishing name but which incorporates airfoil section blades, large hubs and general streamlining suitable for operation against pressure. Such a wheel is illustrated in Fig. 1. Actually, any axial flow fan when creating pressure might more accurately be called a *spiral flow* fan since the air cannot both enter and leave the rotor in a true axial direction. It is only when fitted with guide vanes at the inlet or diffuser vanes at the discharge that the air flow through the fan is truly axial.

The advantages of an axial flow type of fan have long been recognized—the prime advantage being the inherent ability to handle large volumes of air in a small space and with a straight-through blow, thus frequently eliminating awkward and space using duct formations. The broad field of application of propeller fans and disk fans bears witness to this. These fans were usually limited in application to those installations where the resistance to flow was low and comparatively stable. Variations in pressure were apt to cause wide variations in the volume of air handled and, in many designs, an increase in resistance was accompanied by a large increase in horsepower consumption. In addition, efficiencies were low, being materially below those prevalent with centrifugal fans. When operating at free delivery, these low efficiencies were not too serious since the power consumption was small anyway for the volume of air being handled, and good efficiencies at free delivery with centrifugal fans were also difficult to obtain without using excessive sizes. When, however, these types of fans were used against even moderate resistances, power consumption was usually much higher than with reasonable sizes of centrifugal fans.

Design

Axial flow fan development had its origin in the widespread research of the aeronautical sciences, which has been intense throughout the world in the last two decades. As a logical complement to aerodynamic experimentation, airplane propellers were adapted as prime movers for the air in wind tunnels and fan development along these lines followed in many places. The beginning of this development was in Europe and it is interesting to note that as long as 15 years ago commercial fans bearing all the major features of the present day fans were available in Europe. Figs. 2 and 3 show such fans as illustrated in English catalogs published in 1931 (note the streamlining, large hubs, twisted blades and airfoil vanes).

With the abundant supply of data on airfoil sections available through aeronautical research, it was possible to apply the knowledge to a fan wheel for the purpose of creating airflow just as it was applied to a propeller, with the desire to produce air thrust. The axial flow fan blade roughly follows the appearance of a propeller in that a cross-section of either blade has the familiar airfoil shape and the blade is twisted to greater angles as the center of either type rotor is approached. Applying aerodynamic principles to the design of an axial flow fan shows that the propeller

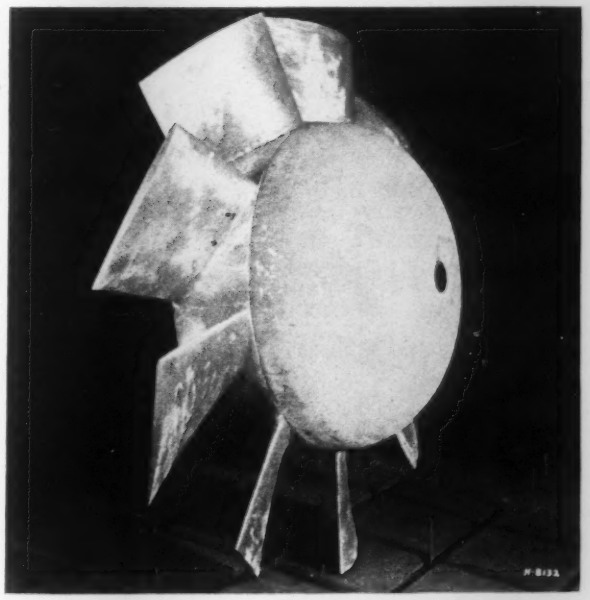


Fig. 1—Axial flow wheel

*Assistant Chief Engr., Buffalo Forge Co. Member of ASHVE.
**Mechanical Engr., Buffalo Forge Co.
Presented at the 50th Annual Meeting of the American Society of Heating and Ventilating Engineers, New York, N. Y., January, 1944.

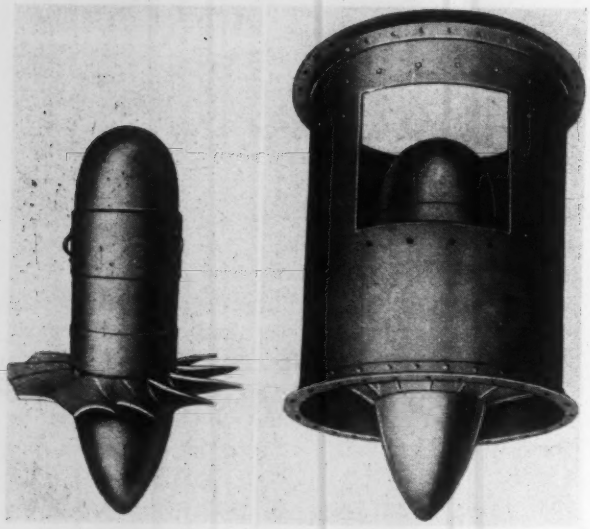


Fig. 2—Early English fan

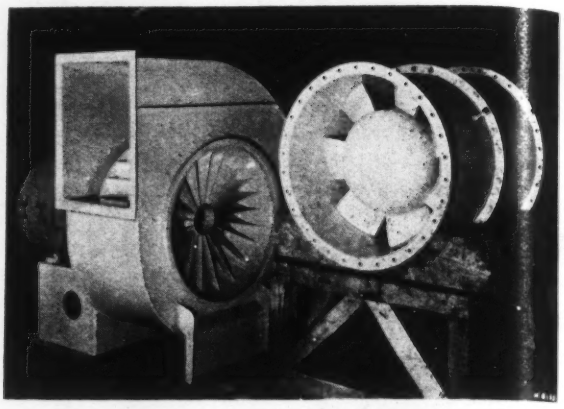


Fig. 4—Comparison of sizes

type blade with practically no hub at all is fundamentally unable to produce high pressures efficiently. Because the linear velocity of the blade near the center of the wheel is so low compared to the tip velocity, it is not practical to build such a wheel to operate at low relative air velocities. At points on the fan curve away from free delivery, the portion of the blades near the wheel center can do little work, so they are simply eliminated and replaced by hub. Thus it is found that present wheel designs have hubs of 50 per cent, 60 per cent, and sometimes as high as 70 per cent of the wheel diameter.

The combination of twisted blade and large hub thus gives substantially constant flow over all the working face of the wheel, which is essential if high efficiencies are to be attained when working with high pressure differences.

For centrifugal fans, a shallow, wide fan blade indicates a low pressure, high capacity fan. Conversely, a long narrow blade, as in a supercharger, is used for low capacity high pressure conditions. Analogously, small hub axial flow fans are for low pressure, high capacity ratings, while large hub wheels are for high pressure applications.

These characteristic large hubs permit the introduction of the motor in the case of a direct-driven unit, or the bearings, in a belt-driven style, inside the fan without obstructing the air flow. For reasons explained later, the axial flow fan is an inherently high specific speed fan and its outlet velocities are usually higher than with centrifugal fans. The result is that the axial flow fan frequently has a diameter no greater than the outlet of a centrifugal fan. Fig. 4 illustrates the comparative sizes of an axial flow and a centrifugal fan used for the same conditions.

Needless to say, best efficiencies demand streamlining of all parts and careful manufacture with close tolerances. For fans drawing from the room with no duct work on the inlet, belled entrance pieces are usually indicated. For direct connected units, the normal large hub permits locating the motor close to the wheel without obstruction. In special cases, the optimum hub diameter must be exceeded to meet the practical problems of design presented when the motor is larger than normal.

Another axial flow fundamental is that when pressure is produced in a wheel, the air necessarily leaves in a spiral motion. Fig. 5 shows the velocity vector diagram across an axial flow blade section.

From this diagram and description, the inherent spiral nature of the air flow leaving the wheel is evident; also evident is that deviation from a true axial direction is more pronounced as the volume handled is decreased. To correct this spiral motion, stationary guide vanes are used. These recover much of the rotational component of the velocity leaving the wheel and in so doing increase the pressure developed and the fan efficiency. Such vanes can be arranged ahead of the wheel or after it, or both. One type is shown in Fig. 6.

Characteristics

The typical characteristic curves of axial flow fans, the effect thereon of variations in several features of design, and their comparison with common types of centrifugal fans are shown in Figs. 7 to 10. In fairness to the centrifugal fan, it must not be overlooked that the axial flow fan derives many of its characteristics from close adherence to the principles of ideal flow and to maintenance of close manufacturing tolerances. The centrifugal fan with which the comparison is made is of the commercial type in common use where the factors given are often compromised to reduce cost. Were the centrifugal fan to

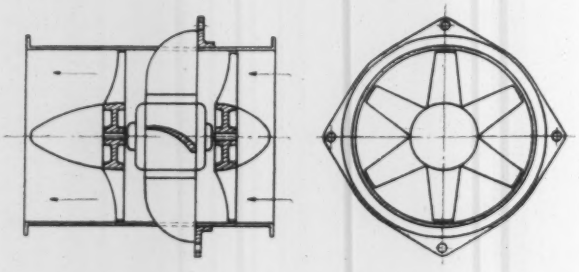


Fig. 3—Early English fan

be as precisely made as the axial flow, regardless of cost, the comparisons, especially of efficiency and noise, might easily be radically changed. Caution must be used in attempting to assign other than comparative or typical value to any such curves. With the many variations of design features, including a multiplicity of airfoil sections, variations in number, size, pitch and twist of blades, percentage hub and type and arrangement of inlet and diffuser vanes, the designer is presented with an infinite number of combinations from which to select. The result is that many characteristics desirable for an individual application may be built into an axial flow fan, although sometimes compromising other desirable characteristics. In addition, the boundaries of the field of exploration of the effect of the various design features are wide, and positive limitations of characteristics resulting from untried combinations, difficult to define.

Fig. 7 shows the effect of various blade angles on the volume-pressure relationship with other design features held constant. The first *curve a* is with a flat pitch, and succeeding curves are with increasingly larger pitches. It will be noted that *curve a* shows a steadily rising pressure characteristic and that the other extreme *curve c* shows the pressure characteristic having a substantial dip. The resemblance to centrifugal fans is immediately apparent where the axial flow with a flat pitch has a characteristic comparable to a backward curve centrifugal fan. On the other extreme, *curve c* has a characteristic bearing a striking resemblance to a forward curve blade centrifugal fan. The unique characteristic of *curve c* is occasioned by the same circumstances in both the axial and radial flow fan in that wheel velocities are high and a majority of the pressure is made available by conversion of the high velocity pressures into static pressures. In the case of an axial flow fan, conversion is made in the diffuser vanes, and in the case of the forward curve fan, in the scroll volute. A fan having a characteristic such as *c* must be selected with caution to insure operation at a stable part of the curve. It would not be suitable for applications requiring a wide range of capacity at constant speed. On the other hand, and again similar to a forward curve centrifugal fan, it has the advantage of giving the most air volume at a given speed, or in other words, permits the use of a smaller unit at the same speed.

Fig. 8 shows the effect on the pressure volume relationship of the addition of inlet vanes and diffuser vanes. Vanes before the wheel or inlet vanes produce the effect of an increased speed and vanes after, commonly called diffuser vanes, raise the pressure curve and lower the specific speed. A propeller on an airplane, even when functioning at low angles of attack, would benefit somewhat from the use of similar vanes called contra vanes, if structural features did not prohibit their use.

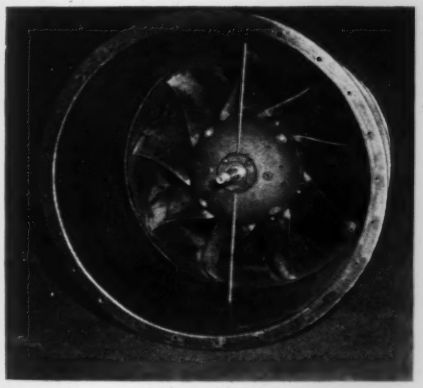


Fig. 6—Interior of axial flow fan

Fig. 9 compares the static pressure, horsepower, and efficiency curves of a medium angle axial flow fan, a backward curve centrifugal fan, and a forward curve centrifugal fan, all selected to meet the same pressure-capacity conditions. Note that some similarity between the pressure curve of this design axial flow fan and a forward curve centrifugal fan still exists. A flatter pitch blade with higher speed or larger diameter would give a characteristic more nearly like the backward curve centrifugal.

The horsepower curves are plotted for percentages of individual horsepower consumptions at the common pressure-capacity conditions. Consequently they indicate the variation in curve shape only, not relative power consumption at the rated condition. Note that the axial flow horsepower curve is approximately self-limiting, showing only a small rise at shut-off. Were a flatter pitch blade used, the self-limiting characteristic might be compromised.

The efficiency curves are drawn in per cent of maximum for each individual fan, and therefore show relative location of peak efficiencies only. The absolute values will vary with design but it can be generally

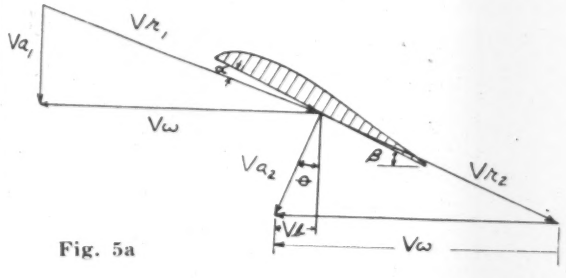


Fig. 5a

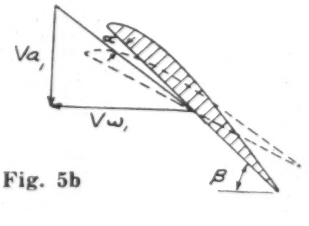


Fig. 5b

Fig. 5—Blade velocity vector diagram

Explanation of Fig. 5

The velocity vector diagram for any section through an axial flow fan blade is shown in Fig. 5*a*. V_{a1} represents the absolute air velocity into the wheel. $V\omega$ is the tangential velocity of the blade which has a pitch angle of β. V_{r1} then represents the resultant or the air velocity relative to the blade. V_{r1} strikes the blade at angle α, the angle of attack.

The air is slowed passing through the wheel and leaves at relative velocity V_{r2} which combined with the tangential velocity $V\omega$ gives an absolute air leaving velocity of V_{a2}. Note that this velocity is not axial in direction but deviates from the axial by angle θ. V_t thus represents the rotational component of V_{a2} which would be dissipated by the spiral motion unless recovered by guide vanes.

The need for a twisted blade is shown in Fig. 5*b* which takes a section nearer the center. Assuming the same absolute air velocity, V_{a1} will be the same, but the tangential velocity, $V\omega_1$, will be decreased in direct ratio to the radii. Thus angle α would be decreased possibly to a negative value if the same pitch were used. An increased pitch as shown permits maintaining a suitable angle of attack. When angle becomes too great for optimum results, the blade is replaced with hub.

Likewise, for very small values of air flow, V_{a1} is decreased for the same value of $V\omega$ and angle α may exceed the angle of stall resulting in inefficient flow.

Fig.7—Effect of blade angle

stated that mechanical efficiencies of axial flow fans are comparable in value to those of centrifugal fans and may exceed them. However, since outlet velocities are frequently higher, the spread between static efficiency and mechanical efficiency might be greater. It should be especially noted that the peak efficiency of an axial flow fan occurs to the right of the curve, that is, toward free delivery. This fact automatically insures a stable operating point even with high pitch blades if the fan is selected to operate at best efficiency.

Noise was always a weakness of early forms of axial flow fans. High specific speed propeller fans could deliver pressure only by operating at excessive tip speeds and by operating to the left on the pressure-capacity curve. They were then out of their best sphere of use and either noisy or very noisy, depending on just how far afield they were.

Only after the introduction of medium pressure axial flow fans could moderate pressure ratings be met by fans operating within their proper sphere. Noise levels were more satisfactory, but only after extensive research were they reduced to a point comparable with centrifugal fans. As a result of this work, carefully designed medium pressure axial flow fans are today run at speeds which noise had always prohibited for exacting applications. Today within the medium pressure range encountered in ventilation, the axial flow fan may be as quiet as the centrifugal, and if carefully made, it may be even quieter. Such a fan demands mechanical perfection greater than now exists in a commercial centrifugal fan, so the cost of a refined axial flow fan often might not be justified by the use. As this perfection is sacrificed to price, the noise advantage of the axial flow fan over the centrifugal can quickly disappear. For this reason every axial flow fan, regardless of design, cannot be indiscriminately considered quieter than a centrifugal fan.

Tip speed is a poor indicator of the respective noise merits of two different kinds of fans. A fan with one combination of design features may operate at a higher speed and yet have a lower noise level than a fan with other features. The only way to properly judge the sound ratings of different kinds of fans offered for a particular service is to compare their noise ratings. The noise produced by any given fan will vary greatly with the speed. Since the reduction in speed means a reduction in pressure, it is imperative that those systems where noise must be low should be designed for minimum resistances. Variable speed drives where feasible insure operating at all times at the minimum noise level consistent with the system demands. Maximum noise is thus generated only when maximum flow is required.

Noise consciousness will continue to increase so the noise level will become a more important factor in the economic selection of a fan. Noise ratings will put selection on a more tangible basis. System

[1]For constant size, constant rating point

$$\text{Db change} = 50 \log_{10} \frac{\text{RPM}_2}{\text{RPM}_1}$$

Thus, to double the speed of a fan will raise the noise level by 15 db.

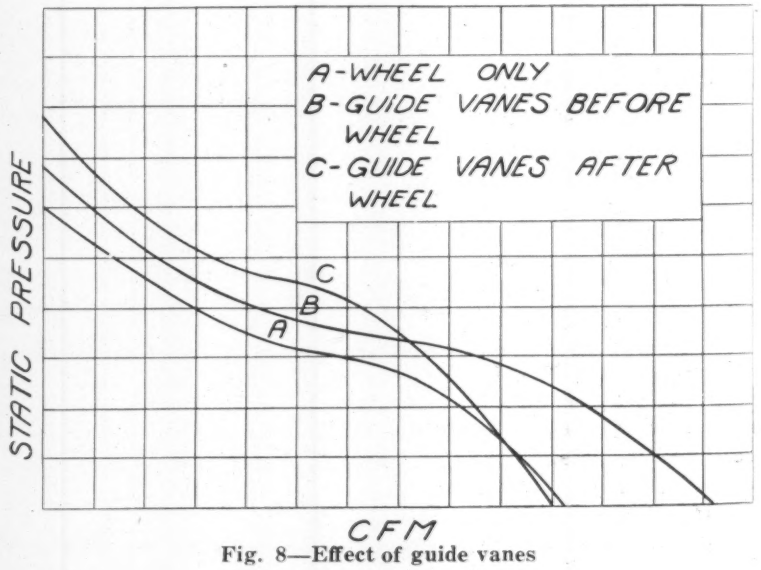


Fig. 8—Effect of guide vanes

sound treatment is often economically warranted as with centrifugal fan installations, and the problems involved are similar, but the cost of treatment must be balanced against the difference in fan costs. Where sound treatment must be drastic enough to increase operating pressures, both installation and operating costs pyramid.

Comparative noise curves of axial flow and backward curve centrifugal fans are shown in Fig. 10. Superimposed are efficiency curves transferred from Fig. 9. Note that the low noise level on the axial flow fan is to the right of the curve and that there is a sharp rise of approximately 10 db near the center. This is characteristic of both low and high angle fans. The backward curve centrifugal fan has a broader sound range devoid of critical points. For both types the region of minimum noise level coincides with the region of maximum efficiency.

All these characteristic pressure, horsepower, efficiency and noise curves evidence that the optimum operating point of an axial flow fan is nearer free delivery than of the centrifugal and in that region even a high pitch fan gives stable operation. However, if the system characteristic of the application is varying or indefinite, a centrifugal fan insures more trouble-free operation.

Application

In applying axial flow fans to systems requiring little or no static pressure, performances better than with centrifugal fans can be obtained. However, a propeller or disk fan is usually indicated, since its lower cost more than offsets any loss in efficiency.

Maximum pressures for which axial flow fans may be designed cannot be categorically stated, especially if multirotor units are included. Limits are, however, well above the ventilation range and therefore beyond the scope of this paper. Suffice it to say that a single stage fan of the general construction under discussion is capable of meeting any pressure demand imposed by any ordinary ventilation requirement.

Pressure alone, however, is not a true criterion of the proper fan selection. The pressure-capacity-speed relationship must be considered. In order to see how the axial flow fan fits into the fan family as it now exists, it is necessary to consider specific speed.[2] Specific speed is a non-dimensional indication of such pressure-capacity-speed relationship and may be defined as the revolutions per minute at which a fan of any one type would operate to furnish 1 cu ft of air per minute at 1 in. pressure. Numerically, this would be:

$$N_s = \frac{\text{RPM} \sqrt{\text{CFM}}}{(P_s)^{3/4}}$$

where N_s = specific speed
RPM = rev. per min. of fan
CFM = cubic feet per minute of fan
P_s = static pressure of fan in inches of water

From the formula, values of specific speed may be computed for each point on the pressure-capacity curve. Disregarding slight changes in efficiency with fan size, these values would then hold for any one design of fan running at any speed regardless of size. These values may then be plotted against any other characteristic such as efficiency whence from the pressure-capacity-speed requirements of any application, the efficiency of the correct size of any type of fan may be determined. When such curves are drawn for a complete family of fans, the best fan selection for any given condition may be readily de-

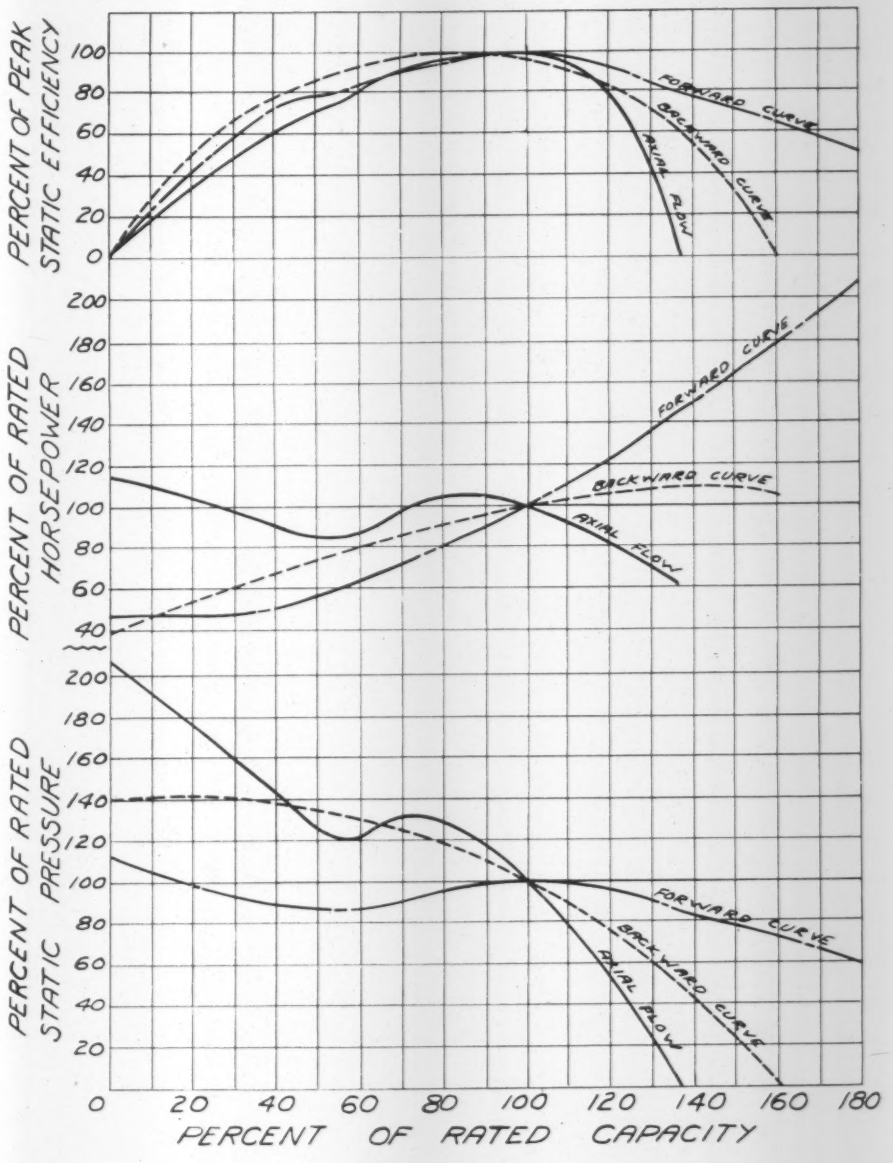


Fig. 9—Comparison of characteristic curves

[2]For a more complete discussion of specific speed see *Fan Engineering.*

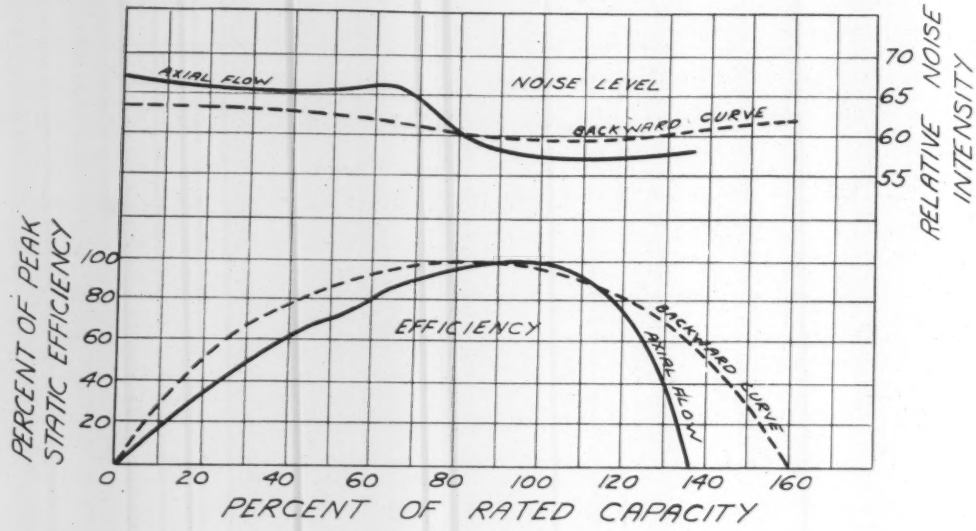


Fig. 10—Comparison of noise curves

STATIC PRESSURE

termined. Such a group curve is shown in Fig. 11.

This curve is plotted between per cent of individual peak static efficiencies and specific speeds for several types of centrifugal and axial flow fans. *Curve a* indicates a very high pressure-low capacity blower such as a turbo compressor or supercharger. *Curve b* represents a high pressure blower, *curve c* a medium pressure fan commonly used for mechanical draft, *curve d* a forward curve ventilating fan, and *curve e* a backward curve ventilating fan. It is thus seen that the range of specific speed from 0 to 60,000 is well covered by centrifugal fans operating at optimum efficiencies. If axial flow fans were not available, 60,000 specific speed would be about the limit of good efficiency. If the pressure-capacity-speed requirements of an application called for higher than 60,000, it would be necessary to drop the speed and use a larger fan to fall within an efficient operating range.

Also plotted are two representative axial flow fan *curves f* and *g* showing their normal range of specific speed to be above 60,000. With this range covered by efficient fans, it is now frequently possible to increase the speed of an application requirement and use a smaller fan at less cost. The conclusion should not be drawn from these curves that axial flow fans cannot be designed for specific speeds below 60,000, but rather that above that limit they are definitely indicated. Conversely, at low specific speeds the centrifugal fan is definitely indicated.[3]

Obviously, there is an overlapping region where considerations other than efficiency decide the choice. Such considerations are mainly cost, space, and reliability. Future costs are difficult to predict, but at present there is evidence that when both types of fans are made comparable in performance they compare in cost. In this respect it must be remembered that while the axial flow fan is smaller, lighter, and frequently runs at higher speeds, it must be more precisely made, and this precision is

[3] *Example:*
Given: Fan to handle 3,000 cfm at 3 in. static pressure, direct connected to 1750 rpm motor.

Compute: $N_s = \frac{1750\sqrt{3000}}{(3)^{3/4}} = 42{,}000$

42,000 specific speed falls within a range suitable for a centrifugal fan which would then be the obvious selection although the use of an axial flow might not be entirely excluded. If space saving were important, the obvious attempt should be made to decrease the size by increasing the speed. Such a change might also result in a lower cost. Increasing speed to the next higher motor speed of 3500 rpm—

$$N_s = \frac{3500\sqrt{3000}}{(3)^{3/4}} = 84{,}000$$

84,000 specific speed would be outside the range of good efficiency for a centrifugal fan and an axial flow fan would be definitely indicated.

With the data given, investigation should then be made of the relative noise levels, space requirement, power consumption and cost, to determine the best selection.

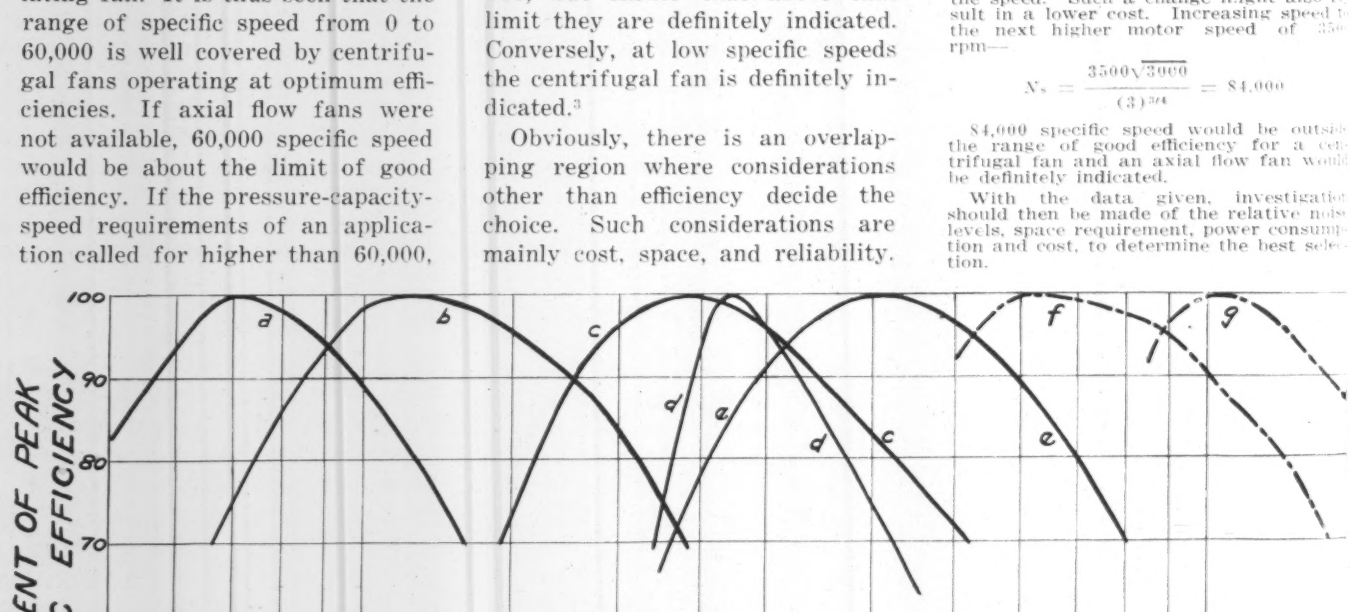


Fig. 11—Specific speed—efficiency curves

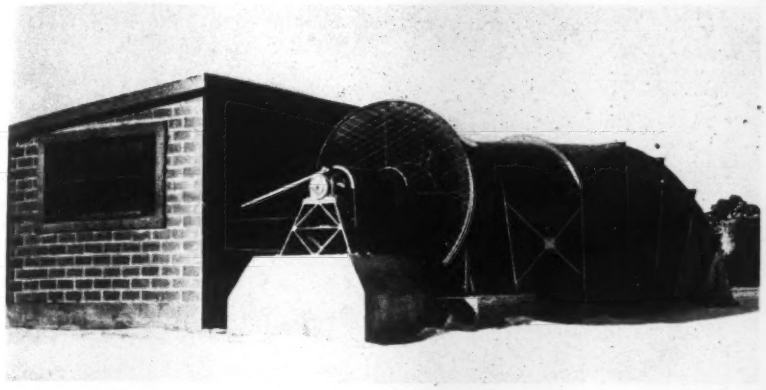


Fig. 12—Mine fan installation

reflected in the manufacturing cost. The smaller space requirements of an axial flow fan will frequently be the deciding factor since space saving is the axial flow fan's chief virtue. That feature alone dictates its selection in many cases where other factors might otherwise indicate the choice of a centrifugal fan. As for reliability of service, installations handling contaminated air or where maintenance shutdowns disrupt vital service are better left to the centrifugal fan. Furthermore, the centrifugal fan is better adapted for applications where hot gases are handled. Axial flow fans are used to handle heated air but the factors in favor of their use must bear an additional burden to offset some sacrifice in reliability and serviceability and an increase in cost. As for reliability of performance, the pressure, horsepower and noise characteristics of a backward curve centrifugal fan are optimum where the system resistance is indefinite or variable.

One prime application where space conservation is requisite is in mine ventilation, since air quantities are often extremely high and pressures comparatively low. Fig. 12 shows an early mine fan installed above ground, but underground installations present the greatest opportunity for economy. The saving in cost of excavation alone may easily decide the choice. A comparable application might be in future vehicular tunnels where specific speeds are suitable for axial flow fans and expensive buildings must be constructed just to house the ventilating equipment.

As is only fitting, the aeronautical laboratories and airplane engine plants have found many uses for the axial flow fan. See Fig. 13. A perfect example is for drawing cooling air over engines undergoing performance or run-in tests. With the engine at one end of the engine mount and an axial flow fan at the other, pressure losses and installation costs are minimized. A similar cooling use is for large vehicles such as diesel locomotives and tanks where the amount of work to be done and the space value preclude the use of any less efficient or more bulky type of fan.

Of course, the ideal application for axial flow fans is on ships, where their small size, light weight, high efficiency, and quiet operation are so advantageous. By using high speed motors, units can be built to fit directly in main trunks with little change in duct design. Navy requirements and the foresight of naval engineers provided the real impetus for axial flow fan development on a large scale. Quiet operation with accompanying improvement in efficiency, decrease in weight, and broadening of pressure ranges was acquired without sacrificing ruggedness, since naval installations must withstand concussion and shock. Details of this application are given in a recent paper.[1] With the vast quantity of fans required, completely standardized units could be adopted, but only after the naval engineers felt the optimum in performance had been attained. As a result of this insistence on excellence before standardization, axial flow fans will be available in many sizes and designs for post-war industrial applications and their successful operation will have been proved.

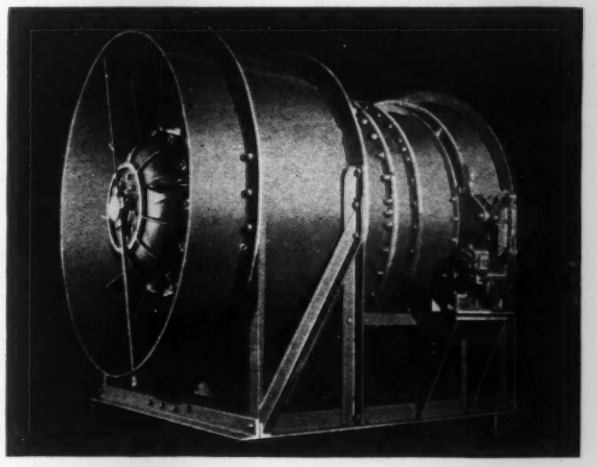


Fig. 13—Engine ventilating fan

In the future there will be many ventilating applications where the axial flow fan will replace the centrifugal largely on the basis of space saving. The air conditioning industry will find many places for this fan, as will the drying and electrical industries. In fact, nearly every industry will find it worthy of consideration.

In conclusion, it might be said that the true axial flow fan was born in the aeronautical research laboratory, received its basic training in the Navy, and is ready to join the industrial army. It has fields of application where its use is definitely indicated but it can also be misapplied. It fills a gap in the specific speed chart by providing a high efficiency unit between centrifugal fans and propeller fans. Its range overlaps both of these sufficiently that it will replace many disk and propeller fans and some centrifugal fans. It is not, however, a universal fan to be indiscriminately applied, and the choice between an axial flow and a centrifugal fan must still be intelligently made by the engineer.

[1] Warship Ventilating, Heating and Air Conditioning, by Comdr. T. H. Urdahl and W. C. Whittlesey. (ASHVE Journal Section, Heating, Piping & Air Conditioning, February 1943.)

New Officers Elected for 1944

S. H. Downs
Kalamazoo, Mich.
President

C.-E. A. Winslow
New Haven, Conn.
First Vice-President

A · S · H · V · E ·

Alfred J. Offner
New York, N. Y.
Second Vice-President

L. P. Saunders
Lockport, N. Y.
Treasurer

SUMMARY OF LOCAL CHAPTER MEETINGS

CHAPTER	MEETING DATE	SUBJECT	SPEAKERS	OTHER FEATURES	ATTENDANCE	ATTENDANCE RATIO*
Cincinnati	Dec. 14	Radiant Heating Systems	C. A. Hawk, Jr., A. M. Byers Co., Pittsburgh, Pa.	O. W. Motz reported for the Library Committee G. V. Sutfin was appointed as Representative on Nominating Committee and H. A. Pillen as Alternate	40	0.93
Connecticut	Nov. 17	The Society's Activities in War Time	M. F. Blankin, Pres. ASHVE, Philadelphia, Pa.	Informal Dinner Meeting—No business conducted	38	
Illinois	Dec. 13	What 500 Installations Have Revealed About Radiant Heating (illustrated with slides)	C. A. Hawk, Jr., A. M. Byers Co., Pittsburgh, Pa.	John Howatt reported for Engrg. Advisory Committee for Fuel Conservation Messrs. Locke, Kearney, Mitterdorff and Porter submitted reports	100	0.68
Iowa	Dec. 14	Past and Present War Markets	H. B. Dennis, Regional Zone Mgr., Darling Valve and Mfg. Co.	C. E. Helstrom and W. W. Stuart were appointed Delegate and Alternate on Nominating Committee	15	0.63
Kansas City	Dec. 27	Control of Air Volumes Housing Research as an Aid to the Heating and Ventilating Engineer	R. E. Bade, B. F. Sturtevant Co. Carl F. Boester, St. Louis, Mo.	D. M. Allen and W. A. Russell were appointed as Delegate and Alternate on both Nominating Committee and on Chapter Delegates Committee	50	0.56
Massachusetts	Dec. 21	Measurement of Heat Transfer Through Insulators	L. R. Vianey, M. I. T.		25	0.44
Michigan	Dec. 13	Fuels of the Future Kilgore Bill (now under consideration in Washington)	Ralph A. Sherman, Battelle Memorial Institute, Columbus, Ohio W. C. Randall	Treasurer and Chairman of Membership Committee submitted reports	43	0.44
Minnesota	Dec. 16	Fuel Oil Rationing John Alden, Ass't Fuel Oil Rationing Specialist of St. Paul, also discussed the fuel situation F. B. Rowley, R. C. Jordan and C. E. Lund, of the University of Minnesota joined in the discussion	G. O. Lundman, Dist. Fuel Oil Rationing Specialist, St. Paul Frank Thompson, Chm., Fuel Oil Panel, War Price and Ration Board, Minneapolis O. A. Steele, Pres. Better Homes Heating, Inc. Ben Ferris, Minneapolis Civic and Commerce Assoc.	R. C. Jordan was appointed Repr. on Nominating Committee and F. B. Rowley as Alternate M. S. Wunderlich was designated as Delegate to Annual Meeting in New York, and A. B. Algren was named as Alternate	24	0.25

Chapter	Meeting Date	Subject	Speakers	Other Features	Attendance	Attendance Ratio*
Montreal	Dec. 13	Annual Meeting T. H. Worthington and A. B. Madden were appointed as Chapter delegate and alternate to Annual Meeting of Society, and as Representative and Alternate on Nominating Committee	None	Election of Officers as follows: Pres., A. M. Peart; Vice-Pres., R. O. Boland; Treas., J. B. Dykes; Sec'y, Leo Garneau; Board of Governors: F. A. Hamlet, A. B. Madden, F. G. Phipps, E. W. Twizell, R. G. Wormley	36	0.50
Nebraska	Dec. 14	The Government Fuel Conservation Program	Carl O. Ruchte, Dist. Fuel Rationing Officer, OPA	B. G. Peterson was appointed as Chapter Delegate and as Alternate on Nominating Committee; D. E. McCulley was appointed as Representative on Nominating Committee	15	0.80
New York	Dec. 20	Annual Christmas Party		James A. Donnelly was introduced as one of oldest charter members of Chapter and Life Member of Society	122	0.25
Northern Ohio	Dec. 13	Electronics Electronics at Work (a sound film was shown)	Carey Mann and E. H. R. Pegg, both of Westinghouse Electric and Mfg. Co.	G. B. Preister and R. L. Clark were appointed as delegate and alternate on Chapter Delegates Committee L. S. Ries was appointed as representative on Nominating Committee and John James as alternate	40	0.56
North Texas	Dec. 13	W. A. Catlett was host to Chapter at a venison dinner	Entertained by J. B. Carlisle (ventriloquist) with aid of "Red McGuffy"	Election of officers: Pres., L. C. McClanahan; Vice-Pres., E. T. Gessell; Sec'y-Treas., E. J. Stern	93	0.66
Oregon	Dec. 9	Hydraulic couplings	T. J. White, American Blower Corp., San Francisco		19	0.39
Philadelphia	Dec. 9	Blood Plasma and the Desiccation of Foods in the Frozen State	Dr. Earl E. Flosdorf		57	0.47
Washington	Dec. 8	Airport Planning	Lt. Col. Thos. E. Greacen, Army Air Forces	Announcement that T. A. Cheasley, Bureau of Mines, was appointed Field Dir. of Fuel Conservation	36	0.48
Wisconsin	Dec. 20	Car Air Conditioning and Car and Truck Refrigeration	C. G. Callow, Sales Mgr., Refrigeration Div., Waukesha Motors		27	0.45

*The attendance ratios shown represent the meeting attendance divided by the Chapter membership. These will be useful as a partial indication of interest shown by local chapter members in various types of subjects programmed by other local chapters and may be helpful in deciding on subjects for other chapter meetings.

COMMERCIAL STANDARD FOR MINERAL WOOL

On January 7, the National Bureau of Standards submitted to the trade for acceptance a Recommended Commercial Standard for mineral wool: Blankets, Blocks, Insulating Cement and Pipe Insulation for Heated Industrial Equipment (TS 3632).

This standard applies to high temperature installations of mineral wool. It covers the thermal conductivity, density, standard sizes and tolerances for the different types of mineral wool insulation.

Copies of the proposed standard may be obtained from the Division of Trade Standards, National Bureau of Standards, Washington, D. C.

DEATH OF F. N. PARSONS

The untimely death of Felix N. Parsons from a heart attack on Sept. 7, 1943, at Sheffield, Ala., has just been reported and the officers of the Society have expressed their sincere sympathy to his widow and family who survive.

At the time of his death at the age of 46, Mr. Parsons was assistant mechanical engineer at U. S. Nitrate Plant No. 2, Wilson Dam, Ala. After his preparatory schooling in Dallas he entered the University of Texas in 1916 and before graduation he went into the army. From 1923 to 1936 he served in the army and then retired because of physical disability.

Mr. Parsons then designed a great many heating, ventilating and air conditioning systems while employed by the Georgia Pine Mountain Corp., North American Rayon Corp., The Panama Canal Zone, and the Tennessee Valley Authority. During his service with the army he served as an assistant professor of military science at the University of Alabama. He was a native of Texas and joined the Society in 1943. He also held membership in the Canal Zone Engineers Assn. and American Legion Post No. 27, Sheffield, Ala.

W. B. GRAVES, LIFE MEMBER, DIES

One of the Society's Life Members, Williard B. Graves, Chicago, Ill., died at the age of 80 on Nov. 15, 1943. At the time of his death Mr. Graves was the head of the W. B. Graves Heating Co., and had been in the heating business for 61 years as he started his apprenticeship in Sept., 1882, in Dunkirk, N. Y.

After a year with the Craig Reynolds Foundry, Dayton, O., Mr. Graves spent 3 years with Edward P. Bates, Syracuse, as superintendent of the Binghamton branch, and the next 3 years as superintendent of F. W. Oives Co., Niagara Falls, N. Y. In 1895 he started with Graves Bros., Chicago, and later became proprietor of the W. B. Graves Co.

Mr. Graves joined the Society in 1906 and was granted Life Membership in 1933. He was always an active organization worker and was a regular attendant at Illinois Chapter meetings and he was a very active worker in the Heating, Piping and Air Conditioning Contractors National Assn.

The Officers and Council greatly regret the loss of an active and loyal member and express their sincere sympathy to his family.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 45 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by February 20, 1944, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ACHESON, LOUIS K., Head of Mech. Research Lab., The Hoover Co., North Canton, Ohio.	*G. P. Daiger C. W. Studer	*M. D. Stahl *C. E. Boger
ALEXANDER, GRANVILLE P., Secy., Heating, Piping & Air Conditioning Contractors Philadelphia Association, Philadelphia, Pa.	M. F. Blankin A. E. Kriebel	C. F. Dietz H. H. Erickson
BAAK, WALTER J., Branch Mgr., Minneapolis-Honeywell Regulator Co., Omaha, Nebr.	C. E. Wiser B. G. Peterson	E. F. Adams G. E. Merwin
BARAGAR, JAMES S., DeWitt C. Griffin & Associates, Spokane, Wash. Associate in charge of office.	DeW. C. Griffin E. O. Eastwood	S. D. Peterson E. H. Langdon
BOELTER, L. M. K., Assoc. Dean, College of Engineering, University of California, Berkeley, Calif.	G. L. Tuve M. F. Blankin	Cyril Tasker A. V. Hutchinson
CLARK, HARRY E., Mfrs. Agent, Houston, Tex.	R. F. Taylor F. C. Brandt	A. F. Barnes A. M. Chase, Jr.
COBURN, JOSEPH B. V., Combustion Engr. & Service Engr., International Chimney Corp., Buffalo, N. Y.	M. C. Beman B. C. Candee	R. C. Siegel S. M. Quackenbush

DARBY, F. NORMAN, Engr. in charge of Htg. & Vtg. Section, Hull Div., Sun Shipbuilding & Drydock Co., Chester, Pa.	F. D. Crew A. G. Dome	Mortimer Trangot M. F. Blankin
DARRAH, RICHARD D., Sales Engr., Dravo Corp., Pittsburgh, Pa.	P. C. Strauch *R. M. Rush	J. F. Collins, Jr. B. B. Reilly
DOERFUSS, HARRY W., Sales Engr., Warren Webster Co., Philadelphia, Pa.	M. F. Blankin Karl Rugart	Alexander W. Luck A. E. Kriebel
DOING, LARABEE J., Engr., U. S. Army Engineers, Denison, Tex.	M. C. Brown D. W. Harrington	E. T. Gessell J. A. Ray
EQUI, FERDINAND F., Half Partner, Stevens & Equi, Bridgeport, Conn.	F. E. Hockensmith L. E. Seeley	C. J. Lyons J. R. Smak
FLANIGAN, WILLIAM P., Engr., Lloyd E. Mitchell, Inc., Baltimore, Md.	J. DeB. Sheppard E. H. Taze	E. L. Crosby P. J. Vincent
GRISWELL, HENRY D., Vice-Pres., Hosmer Stokol Corp., Indianapolis, Ind.	W. A. Bevington J. H. Niesse	G. O. Jackson S. E. Fenstermaker
HINKLEY, HARLAN B., Engr. Custodian, Board of Education, Chicago, Ill. *(Reinstatement and Advancement)*	C. E. Price K. C. Porter	F. P. Keeney C. M. Burnam, Jr.
HOWARTH, WALTON E., Designing Engr., Wm. L. Cassell, Mech. Engr., Kansas City, Mo.	R. B. Mason L. T. Mart	P. C. Leffel M. M. Rivard
HULL, EVERETT O., Engr. Designer, Skidmore, Owings, Merrill & Andrews, Oak Ridge, Tenn.	R. R. Kegarise O. W. Armspach	E. M. Mittendorff S. I. Rottmayer
JOHNSON, RAYMOND C., Dir. of Lab., Anthracite Industries, Inc., Primos, Delaware Co., Pa.	H. J. Rose A. J. Johnson	J. S. King R. A. Protheroe
KELL, JOHN R., Chief Htg. & Vtg. Engr., Dr. Oscar Faber, Cons. Engr., St. Albans, Herts, England.	J. N. Russell G. N. Haden	G. J. Happerfield R. A. Crittall
LAMBERT, EDWARD H., Mgr. Eastern Div., McQuay, Inc., Minneapolis, Minn.	J. W. Markert T. H. Urdahl	J. H. Fogg J. G. Muirheid
LAMBERT, EVERETT C., Air Cond. & Industrial Refrig. Supvr., Westinghouse Electric Elevator Co., Philadelphia, Pa.	W. J. Searle, Jr. R. J. Lee	H. B. Prewitt R. F. Hunger
LAWRENCE, JOHN F., Engr. Designer, Skidmore, Owings, Merrill & Andres, Oak Ridge, Tenn.	R. R. Kegarise O. W. Armspach	E. M. Mittendorff S. I. Rottmayer
LESTER, WM. L. G., Vice-Pres., Abbott Lester & Co., Inc., New York, N. Y.	J. A. Heller H. W. Fiedler	H. J. Ryan A. V. Hutchinson
MARSDEN, EDWARD C., Pres., Marsden & Wasserman, Inc., Hartford, Conn.	P. D. Bemis J. R. Smak	L. O. R. Clark *H. B. Van Jelin
MEDCALF, LLOYD C., Cons. Engr., Heating Power Equipment, Mt. Vernon, N. Y.	E. J. Ritchie R. W. Cumming	C. R. Hiers Thomas Baker
MENDITCH, BARNEY, Ht. & Air Cond. Engr., American Htg. Co., Washington, D. C.	A. P. Mergardt R. K. Thulman	*T. F. Cleary *S. H. Patton
NOTKIN, JAMES B., Mech. Engr., Puget Sound Navy Yard, Bremerton, Wash.	L. L. Bysom E. O. Eastwood	M. N. Musgrave E. J. Rosen
PARKES, C. H., Owner, C. H. Parkes, Dodge City, Kan.	E. A. Cline W. A. Russell	E. K. Campbell R. P. Campbell
PORTER, HUGH T., Vice-Pres., W. B. Connor Engineering Corp., New York, N. Y.	F. H. Munkelt C. R. Hutcheon	R. D. Randall H. M. Parent
ROEPKE, GEO. E., Engr. in charge of Refrigeration, Alco Valve Co., Kirkwood, Mo.	L. R. Szombathy E. E. Carlson	B. C. Simons G. E. Becker
SCHMITT, WILLIAM C., Student, Rensselaer Polytechnic Institute, Troy, N. Y.	A. G. Schubert *E. A. Fessenden	*G. K. Palycove *J. G. Fairfield
SCOTT, ANGUS C., Traveling Rep., Hall-Neal Furnace Co., Indianapolis, Ind.	F. S. Boone G. A. Voorhees	L. W. Clark Frank Morrison
SLUDER, CLARENCE T., Mech. Engr., Federal Housing Administration, Washington, D. C.	R. S. Dill R. K. Thulman	P. R. Achenbach R. H. Feltwell
STEEVES, DONALD R., Service Mgr., Iron Fireman Manufacturing Co. of Canada, Ltd., Toronto, Ont., Canada.	W. C. Kelly D. O. Price	H. S. Moore H. R. Roth
STEIN, HERMAN W., Dir. of Research, Engrg. Dept., Celotex Corp., Chicago, Ill.	P. D. Close J. H. Bracken	R. T. Miller C. E. Price
STEVENS, WILLIAM B., Partner, Stevens & Equi, Bridgeport, Conn.	F. E. Heckensmith L. E. Seeley	C. J. Lyons J. R. Smak
STEWART, JOHN L., Gen. Supt.-Engr., California—Fresno Air Conditioning Co., Fresno, Calif.	J. C. Hemingway, Jr. H. E. Newman	E. W. Howes C. D. Williams
SULLIVAN, JOHN R., Foreman, U. S. Naval Air Material Center, Navy Yard, Philadelphia, Pa.	M. E. Barnard R. S. Arnold	*H. C. Bartholomew F. N. Keeling
TAGGART, ROBERT F., Mech. Engr., O. W. Motz, Cons. Engr., Cincinnati, Ohio.	G. V. Sutfin W. A. Evans	H. E. Sproull A. Buenger
VAMOS, GEORGE, Engr. A. T. Burt, Ltd., Wellington, New Zealand.	H. A. L. Vale J. B. Clark	E. M. Taylor
WARD, JOSEPH A., Pres., Abbott Lester & Co., Inc., New York, N. Y.	J. A. Heller H. W. Fiedler	H. J. Ryan A. V. Hutchinson
WELCH, BUSTER, Mech. Engr., War Dept., 8th Service Command, Dallas, Texas.	J. M. Townsend M. A. Disney	H. W. Presseur I. P. Newby
WOLTERS, HAROLD W., Mgr. Mech. Draft Dept., Clarage Fan Co., Kalamazoo, Mich.	W. G. Schlichting C. R. McConner	S. H. Downs H. A. Brinker
WORTHINGTON, JAMES M., Htg.-Vtg. Engr., Skidmore, Owings, Merrill & Andrews, Oak Ridge, Tenn.	O. W. Armspach R. R. Kegarise	E. M. Mittendorff S. I. Rottmayer
YOST, CLAUDE, Mech. Engrg. Designer, Somwalt & Vinther, Dallas, Texas.	J. A. Bishop E. T. Gessell	J. A. Ray M. L. Brown

*Non-member.

Candidates Elected

In the past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

ALLEN, J. LLOYD, Partner, Allen & Kelley, Architects, Indianapolis, Ind.

BURBO, W. G., Branch Mgr., Ilg Electric Ventilating Co., Boston, Mass.

CLEMENS, J. E., Engr. in charge of Plant Engrg. Dept., Plant No. 3, Allison Division—General Motors Corp., Indianapolis, Ind.

CLUCAS, EDWARD T., Dist. Mgr., Minneapolis-Honeywell Regulator Co., Indianapolis, Ind.

DEHLER, FRANK C., Chemical Engr., The Davidson Chemical Corp., Baltimore, Md.

FINN, CHARLES W., Mech. Engr., Boeing Aircraft Corp., Seattle, Wash.

GATES, JAMES N., Htg., Vtg. & Air Cond. Engr., Air Conditioning Engineering Co., Cambridge, Mass.

GAVIN, JOSEPH A., Mech. Engr., Eastern-Aircraft-Trenton Division, Trenton, N. J.

GOLDNER, HERMAN W., Pres., Herman Goldner Co., Inc., Philadelphia, Pa.

GOOHS, WM. E., Allison Division—General Motors Corp., Indianapolis, Ind.

HALLENBECK, CHARLES W., Dist. Engr., T. C. Heyward, Charlotte, N. C.

HAND, WILLIAM L., Cons. Engr., W. L. H. Engineering Service, Chicago, Ill.

KEIM, EUGENE C., Branch Mgr., U. S. Radiator & Pacific Steel Boiler Corp., Indianapolis, Ind.

MALADY, EDWARD C., Engrg. & Estimating, Brad Snodgrass, Inc., Indianapolis, Ind.

MATTHEWS, R. R., Owner, Matthews Engineering Co., Dallas, Texas.

MULREY, MAURICE D., Owner, T. A. Mulrey & Son, Indianapolis, Ind.

PAYTON, JOHN F., Air Cond. Research Engr., Allison Division—General Motors Corp., Indianapolis, Ind.

PRYER, ALBERT S., Mech. Engr., Eastern Aircraft Trenton Division, General Motors Corp., Trenton, N. J.

ROBERTSON, ARCHIE M., Chief Engr., Stewart A. Jellett Co., Philadelphia, Pa.

ROSS, OTTO C., Owner, Ross Power Equipment Co., Indianapolis, Ind.

SMITH, H. GILMAN, Designing & Sales Engr., Aladdin Heating Corp., Oakland, Calif.

WILE, DANIEL D., Development Dept., Carrier Corp., Syracuse, N. Y.

WRIGHT, CALVERT C., Prof. Fuel Technology, The Pennsylvania State College, School of Mineral Industries, State College, Pa.

ASSOCIATES

APPERT, RICHARD J., Product Engr., Kimberly-Clark Corp., Neenah, Wis.

ARZET, FRED A., Foreman & Me. (Dust Collection Maintenance), Allison Division—General Motors Corp., Indianapolis, Ind.

BAXTER, H. A., Sales Mgr., W. H. Cunningham & Hill, Ltd., Toronto, Ont., Canada.

CARLSON, CLARENCE J., Regional Mgr., Carlson Brothers Co., Detroit, Mich.

COLBY, JOHN R., Pres., Colby Equipment Co., Indianapolis, Ind.

CORRIGAN, JAMES A., Treas., Corrigan Co., St. Louis, Mo. *(Advancement)*

DRUM, ROBERT I., Gen. Foreman, Air Cond., Allison Division—General Motors Corp., Speedway City, Ind.

DWYER, WILLIAM H., Sales Mgr., Control Supply Co., Indianapolis, Ind.

ESKRA, G. N., Sales Engr., Pacific Metals Co., Ltd., San Francisco, Calif.

FOX, W. L., Engr., U. S. Machine Corp., Lebanon, Ind.

HILMER, GEO., Mech. Designer & Engr., Robert & Co., Atlanta, Ga.

HOFFMANN, WALTER A., Engr., L. S. Ayres & Co., Indianapolis, Ind.

KITCHEN, DARLEY E., Owner, Kitchen Coal Co., & Technical Advisor, Fuel Division, Office of Price Administration, Logan, Ohio.

LEE, CARL M., Supvr., Air Cond., Allison Division—General Motors Corp., Indianapolis, Ind.

MARR, J. M., Chief Engr., Aladdin Heating Corp., Oakland, Calif.

MEANS, JAMES MACG., Mfgrs. Agent, Boston, Mass.

NYLAND, J. A., Owner, Nyland Sheet Metal Co., Indianapolis, Ind.

OSBORNE, J. M., Engr. (Field), The Herman Nelson Corp., Moline, Ill.

PHERIGO, FAUN S., Indianapolis Power & Light Co., Indianapolis, Ind.

PROCTOR, CHARLES W., Sales Engr., The Conditioning Co., Inc., Newark, N. J.

SCHNEIDER, EMILE W., Owner, Airflow Htg. & Vtg. Co., New Orleans, La.

SHREEVE, L. DALE, Refrig. & Air Cond. Engr. and Gen. Purchasing Agent, Knapp Supply Co., Muncie, Ind.

THOMPSON, PAUL J., Branch Mgr., National Radiator Co., Philadelphia, Pa.

WEILAND, CARL C., Pres.-Mgr., Central Supply Co., Indianapolis, Ind.

JUNIORS

BLACKMAN, ROBERT C., Power Engr., Allison Division—General Motors, Indianapolis, Ind.

FENSTERMAKER, WARD R., Air Cond. Engr., Allison Engineering Division—General Motors Corp., Indianapolis, Ind.

GALLOWAY, MAX W., Foreman, Allison Division — General Motors Corp., Indianapolis, Ind.

GARDNER, MARVIN K., Naval Architect, U. S. Maritime Commission, Chicago, Ill.

KERBEL, JESSE, Designer-Draftsman, Chemical Construction Corp., New York, N. Y.

YOUNG, GEORGE H., District Mgr., B. F. Sturtevant Co., Boston, Mass.